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We have additional species from

Carolina (Mosasaurus)	1
Mississippi (Platecarpus)	1
Nebraska (Mosasaurus)	1

making with the others from

New Jersey	15
Alabama	7
Kansas	17
A total of	42

Of these I am not acquainted with any which extends its range into any two of the areas above named, while some of the districts possess peculiar genera. It is nevertheless premature to draw any conclusions as to geographical range, as most of the species are known from but few specimens as yet.

Two genera have recently been discovered in Europe, which have been thought to be allied, or belong, to this order. One of these, *Acrodontosaurus* Hulke, rests on the anterior portion of a maxillary bone with part of premaxillary and teeth. These portions are indecisive as to its affinities. It is from the English Chalk. The second form is the *Danubiosaurus* of Bunzel, which its describer refers to the neighborhood of *Mosasaurus*. It is quite plain after an inspection of his description and figures, that it has no affinity to that genus or to the order *Pythonomorpha*. It is from Neue Welt, from the Cretaceous, near Vienna.

The present investigations have added some points of importance to the history of the structure of the order.

First, as to the pterygoid bones. It appears that these elements are thin plates, having a free laminar termination, and are entirely toothless. They articulate with the palatines by a process which fits their posterior emargination. In *Edestosaurus tortor*, they are about half the length of the palatines. They present no indications of ectopterygoid. The bones named by authors pterygoids, in imitation of Cuvier, are elongate palatines, and the external process extending to the maxillaries, is that seen in Varani, serpents, etc., and is at no time distinct from the palatines.

It has also shown that the supposition of Goldfuss and myself, that the palatines of *Mosasaurus* were in contact on the median line, is an error, and that they are more or less vertical plates, as in *Liodon*. The distinction between these genera, then, rests on the coössification of the chevron bones in the former, and their permanent independence in the latter; perhaps the difference in the form of the teeth may also count for something.

Second, as to the parieto-squamosal arch, which is distinctly developed in *Holcodus ictericus* and *Liodon curtirostris* in its parietal part and *H. coryphæus* in the squamosal part. It was quite strong in the species named.

Third, as to the pelvis. This part, which has been observed by Marsh

in *Edestosaurus dispar*, is usually perfect in *Liodon dyspelor*. The pubes are the only elements united below, forming a weak support to the abdomen. The ilia are slender, not united with vertebral processes above, or without indications of such contact. The ischia are the most slender and directed backwards.

Fourthly, in the hind limb. The femur of *L. crassartus* has been described by the writer, and Professor Marsh asserts its existence in *Liodon*, *Clidastes* and *Edestosaurus*. The present collection exhibits both femur, tibia and fibula of *L. dyspelor*, and these elements are now first described. The first mentioned is not larger, sometimes smaller than the humerus, and has a prominent trochanter, nearly connected with the head. The shaft is not curved, and the distal end is expanded. The tibia is a narrow bone expanded at both ends, the fibula is like that of *Plesiosaurus*, but wider, or partly discoid. It has been known to naturalists but not determined. Thus I figured it for *Liodon laevis*,* and Leidy figured it for an upper Missouri species.†

CLIDASTES, Cope.

Proc. Acad. Nat. Sci., Phila. 1868, p. 233. Trans. Amer. Philos. Soc. 1870, 211.

Vertebræ with the zygosphen articulation. [Palatine bones flat and alate, the teeth not exposed at their bases unequally. This point has not been observed in the type species, *C. iguanavus*.]

CLIDASTES CINERIARUM, Cope.

Proc. Amer. Philos. Soc., 1870, 583.

Several individuals from different points near the Smoky Hill River, Kansas.

The largest species.

CLIDASTES VYMANII, Marsh.

Amer. Jour. Sci. Arts, June, 1871.

From two individuals from the Smoky Hill River and its North Fork.

A small species.

CLIDASTES PUMILUS, Marsh, l. c.

From one individual from the Smoky Hill River.

The smallest known Mosasauroid.

EDESTOSAURUS, Marsh.

Amer. Jour. Sci. Arts, 1871, June.

Vertebræ with the zygosphen articulation; palatine bones narrow, partly vertical, the bases of the pterygoid teeth exposed on one side, or pleurodont. (It is uncertain whether the type of *Clidastes* presents this structure or not.)

EDESTOSAURUS TORTOR, Cope, sp. nov.

Vertebræ of the cervical and anterior dorsal regions with round articular faces, not emarginate for the spinal cord. The bodies are elongate

* Trans. Amer. Philos. Soc. 1869, 205. † (Cretaceous Reptiles,) U. S. Tab. viii. fig. 10.

and somewhat contracted, and marked everywhere with finer and coarser striæ. Hypapophyses prolonged on the cervicals, the free one of the atlas with a prolonged keel-like process.

Quadrate bone with long external angle and rather thick anterior ala with broad rugose margin. A prominent obtuse ridge is continued from the external angle to the inferior articular extremity, the distal portion being more acute. A rugose process projects at the point where the posterior hook approaches the body, and is continued as an elevated narrow ridge, parallel to the previously mentioned, to the distal articular surface. A button-like knob appears on the posterior margin of the hook opposite the meatal part. A strong ridge extends on the inner face of the bone from opposite the end of the hook to the base of the great ala. The distal articular surface presents two planes; the narrower at the end of the posterior pair of ridges above described; the larger considerably less distal, like a broad step.

The *maxillary bone* descends regularly in front, uniting with the premaxillary by a minute suture. Its posterior extremity is slender and acute.

The *premaxillary* is short conic, not particularly prominent. The *palatine bone* has a slight expansion on the inner side; on the outer the margin is very narrow.

The *teeth* number seventeen on the maxillary bone. They are compressed, least so anteriorly, and with a cutting edge from base to crown as far as the fifth from the front, in those anterior to that point the posterior edge is discontinued. There are sixteen pterygoid teeth which are smooth and without anterior cutting edge. The *frontal bone* has a low carina along the median line of its anterior portion.

	M.
Length of axis with odontoid process	.078
Diameter of ball of a cervical { vertical	.026
Diameter of ball of a cervical { transverse	.026
Expanse of diapophyses do.	.084
Length of centrum do.	.052
Length of maxillary bone	.363
" ramus mandibuli behind dentary	.31
Length of premaxillary	.04
Total of cranium (=2.33 feet)	.713
Length of pterygoid and palatine	.315
Length of centrum posterior dorsal vertebra	.066
Diameter of ball { vertical	.033
Diameter of ball { transverse	.038

The bones of this species are all light and slender. The elongation of the vertebræ indicate that if their number was of the usual amount, the animal was of more than usually slender proportions. The position in which it was found was a partial coil, the head occupying the inside of a turn of the dorsal vertebræ. As compared with *E. dispar* and *E. velox* of Marsh, the present differs in the lack of depression of the centra of the

vertebræ, especially the anterior, and in various details of structure of the quadrate bones, as well as the larger number of teeth.

Discovered in Fossil Spring cañon in the grey limestone by Martin Hartwell and Sergeant Wm. Gardner. But one specimen was found, which includes the greater part of the cranium, with the vertebræ as far as the lumbar region.

EDESTOSAURUS STENOPS, Cope, sp. nov.

Indicated by a large part of the skeleton of one individual, and fragments of two others. The first includes a large part of the cranium, with both quadrates, and fifty vertebræ, including the axis. The characters are similar to those of the preceding species, but all the bones are more massive, though of the same dimensions.

The teeth are strongly compressed, with cutting edge fore and aft, and with the surfaces distinctly faceted; there are seventeen on the mandible. The palatine bones are stouter than in *E. tortor*, but the teeth are not larger, and are probably as numerous, as they are similarly spaced.

The *vertebræ* exhibit round articular surfaces, those of the dorsal region being rather stouter than the cervical, though the difference does not appear to be so marked as in the preceding species. The anterior caudals possess wide diapophyses. The articular faces are a vertical oval, a little contracted above, sometimes by a straight outline. They preserve a peculiarly elongate form.

The *quadrates*, like those of the last species, have a very prominent external angle. They present various differences which may be regarded as individual; for example, the edge of the great ala is not expanded outwards, but only inwards; the distal articular extremity is wider, the posteriorly decurved hook is more contracted, forming a deeper external concavity behind the external angle. Characters of more importance are the lack of the two ridges which bound the posterior face of the distal end of the bone, that face being thus convex instead of concave, and the process below the meatus is isolated and not continued into a ridge, except internally, when it gives rise to the heavy ridge which extends to the base of the great ala. The button on the posterior aspect of the hook is wanting, its place being taken by a recurvature of the smooth articular face along the margin.

	M.
Length of axis (above)	0.06
Diameter ball { vertical	.027
Diameter ball { horizontal	.027
Length of a posterior dorsal	.069
Diameter ball { vertical	.033
Diameter ball { transverse	.038
Length caudal with flat diapophysis	.033
Depth cup, do.	.031
Width cup, do.	.03
Length mandible (28 inches)	.720
Depth at coronoid process	.150
" " proximal end of dentary	.074
" " distal " "	.02

A fine specimen of this species was found by Martin V. Hartwell near Fossil Spring. Portions of a second were found by Lieut. Jas. H. Whitten on a bluff on Butte Creek.

Both the above species are the most elongate in proportion to their diameter of the order. They are larger in their dimensions than those next enumerated.

EDESTOSAURUS DISPAR, Marsh.

Amer. Jour. Sci. Arts, June, 1871. Smoky Hill River.

EDESTOSAURUS VELOX, Marsh, l. c.

Near the North Fork of the Smoky River.

HOLCODUS, Gibbes, Cope emend.

Vertebræ without the zygosphen articulation. Palatine bones flat, alate, its teeth not unequally exposed at the bases, or not pleurodont.

This genus bears the same relation as regards the palatine bones and teeth, to the genus *Liodon* that *Clidastes* does to *Edestosaurus*, as above defined. The structure of the caudal vertebræ I unfortunately cannot ascertain, and therefore do not know whether they are as in *Clidastes* or *Liodon*. It differs from *Mosasaurus* as it does from *Liodon*, i. e. in the horizontal laminiform palatines.

The name which I use for this genus was originally applied by Dr. Gibbes* of Charleston to a species represented by teeth from the cretaceous of Alabama, but of which no other portions were known. The teeth of the Kansas species now referred to this genus, are very similar in character to those described by Gibbes, so much so as to lead me to believe that when other portions of the *H. acutidens* of that author are known, they will be found to display the more important features here regarded as truly distinctive of the genus. Its place is evidently between *Clidastes* and *Liodon*, the pterygoid bones being those of the former, and the vertical articulations being identical with that characteristic of *Liodon*. In all of the species, traces of the zygosphen appear, but in the H. *coryphaeus*, Cope, the rudiment amounts to a short process directed forwards at the base of each anterior zygapophysis.

The species known as yet are of medium size in the order.

HOLCODUS CORYPHAEUS, Cope, sp. nov.

Characters. Cervical and dorsal vertebræ with the articular surfaces depressed transverse, slightly excavated above for the neural canal. The diapophyses not continued inferiorly to the rim of the cup, on the cervical vertebræ, and not receiving from it a cap of articular cartilage. Occipital crest much elevated, quadrate bone small, the meatal pit depressed between bounding ridges above and below. Rudimental zygosphen not uniting into a keel above. Teeth slender less curved than *H. ictericus*.

Description. This species is chiefly based on one specimen, which in-

* The *Mosasaurus* and allies: Smithsonian Contr. to Knowledge, 1851. 9 Plate.

cludes the greater part of the cranium and seventeen vertebræ, with ribs, Isolated portions of other individuals were also found in the same region of country.

The disproportion between the diameters of the cervical and dorsal vertebræ is more marked here than the species of *Edestosaurus*. The centra are less elongate, though with larger diameter. The cranium is relatively much smaller, the teeth absolutely smaller, though the quadrate bones are of equal size. The general character of the species is stouter, but less strongly armed, and less elegantly built.

The hypapophysis of the *atlas* has a short small keel below. The neural spine of the *axis* is elongate, but less so than in the two *Edestosauri*, truncate behind, with a median groove into which the anterior keel of the neural spine of the third cervical vertebra is applied. The diapophysis of this vertebræ has a short vertical articulating surface, and is continued into a longitudinal keel, which disappears before reaching the edge of the cup. The same process of the axis has a longitudinal parallelogrammic articular surface.

The *supraoccipital* is very thick and is roof-shaped, the keel rising nearly perpendicularly from the foramen magnum.

The *suspensoria* are directed both upwards and backwards, at about an angle of 45° in each direction, and support on their extremities the squamosal bones. These are prolonged, forming part of their appropriate arch. The occipital condyle is transversely oval. The *sphenoid* bone embraces as usual the basi-occipital protuberances; it is not carinate on the median line below. It sends out on each side near the anterior extremity a sub-horizontal laminar process.

The *quadrate* bone is much like that of *H. ictericus*, but is relatively smaller. While the teeth in that species are smaller, the quadrate is larger, hence the difference in the species is in this point quite striking. The external angle is prominent but very obtuse, and is the summit of a very thick obtuse ridge which extends to near the distal articular surface. The posterior hook is much prolonged downwards and has no button-like process or extension of the articular surface on its posterior face. This face presents a strong rib along the meatus and disappearing above the pit, throws the latter into a depression. This is increased by the swelling of the external angular rib. A prominent knob very rugose at the extremity rises beneath the end of the hook, and bounds a concavity between it and the external rib.

The latter closes the concavity by curving round towards the knob above mentioned. A keel rises exterior to the rib, and below it, and continues into the external angle of the articular extremity. Another very prominent keel extends from the knob beneath the hook to the base of the great ala. The articular extremity is transverse, and in one plane.

The *maxillary bone*, is marked with shallow longitudinal grooves. It supports eleven teeth and has a rather steep premaxillary suture descending in front. The nareal expansion in front occurs opposite the fourth tooth.

The *teeth* are rather long slender and incurved and recurved. There is a distinct cutting edge anteriorly and on a greater or less part of the length of the posterior face. The crowns are four or five faceted on the outer face; the inner face is more numerously faceted, and striate-grooved. The section at the base is sub-circular; higher, the outer face is flatter, the inner more convex. The apex is acute and the cutting edges strong.

The *frontal* is narrow, and differs from the other Holcodi here described in having the olfactory groove closed by contraction behind. Both *palatines* are preserved. They support twelve cylindric conic teeth which have recurved apices and striate enamel. The section is a flat transverse oval, where the external transverse process is given off. The shaft of the bone is much expanded inwardly with a thickened margin; exteriorly the margin is thin, and is nearly followed by the series of teeth, whose bases are exposed externally, and are therefore pleurodont. The emargination for the pterygoid is very deep.

	M.
Length of axis with odontoid	0.074
" third cervical	.048
Diameter ball, do. vertical	.021
Diameter ball, do. transverse	.033
Elevation of spine of do. from centrum	.046
Length posterior dorsal	.068
Diameter centrum vertical	.033
Diameter centrum transverse	.048
Length basioccipital and basisphenoid	.084
Elevation occipital crest above floor of foramen magnum	.03
Length suspensorium from foramen ovale	.09
Length os quadratum	.073
Width distal extremity	.036
Length os maxillare	.21
Depth do. at third tooth	.036
Length fourth tooth	.032
" of crown of do.	.021
Length of palatine bone	.155

This fossil was found by the writer projecting from the side of a bluff in a branch of the Fossil Spring Cañon near the mouth of Fox Cañon. The bluff was from 80 to 100 feet in height, and the *Holcodus* was taken from a position forty feet below the summit, from the yellow chalk.

HOLCODUS TECTULUS, Cope, sp. nov.

Established on a number of cervical and dorsal vertebræ of smaller size than those characteristic of the other species of the genus. The centra have not suffered from distortion under pressure. The articular surfaces are depressed transverse elliptic in outline, with a slight superior excavation for the neural canal. A well marked constriction surrounds the ball. There is a rudimental zygosphen in the form of an acute ridge rising from

the inner basis of the zygapophysis and uniting with its fellow of the other side forming a production of the roof of the neural canal. The combined keels become continuous with the anterior acute edge of the neural spine. Thus the form is quite different from that seen in the last described species, and constitutes a lower grade of rudiment. The fact that this zygosphenal roof is separated on each side from the zygapophyses by an acute groove, gives the former a distinctness more apparent than real.

The fixed hypapophyses are short and broad. The centra are not elongate. Those of the anterior dorsals present an obtuse keel below.

	M.
Length of a median cervical	0.043
Diameter of ball of do. vertical	.02
Diameter of ball of do. transverse	.033
Length of anterior dorsal	.042
Width of cup	.032

Found by the author on a low bluff or "break" on Butte Creek, fourteen miles south of Fort Wallace.

Holcodus ictericus, Cope.

Liodon ictericus, Cope, Proceed. Amer. Phil. Soc. 1870, p. 577. Hayden's Geol. Survey of Wyoming and adj. Terr. 1871.

In adition to the two individuals of this species procured by Professor B. F. Mudge in one of his geological surveys, the writer obtained a considerable part of a third from a low bluff on Fox Cañon, south of Fort Wallace. This includes seventeen lumbar, dorsal and cervical vertebræ including axis, with ribs, and a large part of the cranium with both quadrates, occipital and periotic regions, etc. Its characters may be briefly pointed out as follows:

Articular surfaces of dorsal and cervical vertebræ transverse oval, excavated above for neural canal; diapophyses not extending below to the edge of the cup, hence not receiving an area of articular cartilage continuous with the rim. Occipital crest low, oblique. Quadrate bone larger, the meatus depressed between ridges. A button of articular surface on posterior face of hook. Scarcely any rudiment of zygosphen. Teeth small, much incurved, faceted and striate ridged.

Some characters additional to those already derived from the first known examples may be added. *The mandible* supports only twelve teeth. *The palatine* bone is shorter anterior to the external process, and longer behind it than in *H. coryphæus*. In our specimen, the posterior extremity is broken off, yet shows no indication of the emargination for the pterygoid bone an inch behind the position of its anterior extremity in *H. coryphæus*. There are ten teeth on the part preserved, four in front of transverse process (six in *H. coryphæus*), and six (probably seven) behind (six in *H. coryphæus*). The plate is more expanded than in the last named species, especially the thickened inner margin, which only ap-

proaches the basis of the last tooth ; (reaches the tooth line at the fifth in *H. coryphæus.*)

The *occipital* crest is low and directed obliquely forwards from the foramen magnum. The suspensoria are stout, and directed at an angle of 45° in both the superior ard posterior directions. The *basisphenoid* is strongly keeled below. The *quadratum* is like that of *H. coryphæus* in its massive external angle and ridge, but differs in the shorter hook and the non-interruption of the groove between the external angular ridge and the knob below the meatus. The cervical and dorsal *vertebræ* display the same disproportion in size, observed in *H. coryphæus.*

	M.
Length os quadratum	0.081
Width articular extremity of do.	.038
Length dentary bone	.28
" tooth of do. third from behind	.022
" " crown only	.016
" suspensorium from foramen ovale	.108
Total length cranium (23 in.)	.58

HOLCODUS MUDGEI, Cope.

Liodon mudgei, Cope, Proc. Am. Philos. Soc., 1870, 581. Hayden's Survey Wyoming, etc., 1871, p. 581.

The specimen of this species obtained by Professor Mudge on the Smoky Hill River, is the only one known to the writer. The characters distinguishing it are the following :

Vertebræ without rudimental zygosphen. Quadrate bone with plane surfaces from the proximal articular surface and the external obtuse angled ridge to the meatal pit ; the latter therefore not sunk in a depression as the other species.

The frontal bone is like that of *H. ictericus*, furnished with an open olfactory groove on the inferior face ; it is wider over the orbits.

A re-examination of the vertebræ of the type specimen, which I described as having compressed centra, renders it probable that they have been so modified by pressure as to render their normal shape a matter of uncertainty.

LIODON, Owen, Cope, emend.

Trans. Am. Philos. Soc., 1870, p. 200.

Vertebræ withont zygosphen and zygantrum. Palatine bones separated from each other, narrowed, the teeth more or less pleurodont. Chevron bones articulated freely with the caudal vertebræ.

This genus embraces several species from the Kansas Chalk, which range in size from the most usual in the last genus, to the largest known in the order.

LIODON CURTIROSTRIS, Cope, sp. nov.

Characters. Cervical and dorsal vertebræ with transversely oval articular faces, which are little depressed, and though not continued to the

neural arch, are scarcely excavated above for the neural canal. The diapophysis with stout inferior horizontal branch, which is capped by an extension of the articular catilage from the rim of the cup. Occipital crest elevated, sub-vertical. Quadrate broad below; pit sunk between bounding ridges.

Description. There is a great disproportion in the sizes of the cervical and posterior dorsal vertebræ; the centra of the latter are rather more depressed than those of the former. They are similar in proportion to those of the *Holcodi* and shorter than those of the *Edestosauri*. The short axes of the articular faces are sub-vertical. The rudiment of zygosphen is seen in the slight anterior prolongation of the roof of the neural canal. The keel of the hypapophysis of the atlas is short and obtuse.

The greater part of the *cranium* is preserved. The supra-occipital keel is vertical and furnished at the summit with a plicate knob for the insertion of a *ligamentum nuchæ*. The thickness of the walls of the bone is not equal to that in *H. coryphæus* and the suture is a double squamosal *i. e.* with groove along the middle of the edge. The basisphenoid is but slightly keeled below, and is distally expanded into a horizontal plate on each side. The parietals are, as usual, confluent, and send off two light arches postero-laterally for union with the squamosal bone. Between their origins are two sub parallel ridges which disappear, the transverse section of the narrow part of the parietals being rounded. The lateral ridges within the temporal fossæ are obsolete, while the convergent angles which bound the parietal table posteriorly are strongly marked: This table is nearly plane and the *foramen parietale* is large. The *frontal* is narrowed in front, and has an elevated keel along its anterior half. The olfactory groove is not much contracted behind, but is closed by the apex of the rugose area in front of the *foramen parietale*.

The palatine bone is narrow and the external margin is very slight, the bases of the teeth being exposed in that direction. The inner margin is much thickened downwards, but not so as to be a vertical plate. The hinder part of the bone is flat and horizontal, with a long maxillary process. The pterygoid notch falls opposite the second tooth from behind. The whole number of teeth is eleven.

The *jaws* are represented by the greater part of all of the tooth-bearing portions. The maxillary bone is shallowly sulcate on the exterior face. Its proportions are quite similar to those of the *H. coryphæus*, but the teeth it supports are larger and fewer. There are none missing from the extremities of the specimen, the whole number being ten; in *H. corphyæus* there are eleven. The crowns are incurved, faceted externally, and striate-grooved internally; there are cutting edges on front and rear, both strongest near the apex; the anterior continued to the base, the latter wanting on the basal third on median maxillaries. The anterior nareal expanse marks the fourth tooth from the *premaxillary* suture. The *premaxillary* bone is remarkable for its shortness and flatness at the extremity, this part being depressed and scarcely projecting at the lower margin in front of the anterior teeth. These as usual number four.

Both *quadrate* bones are preserved nearly entire. They have the same general character as those of *H. ictericus* and *H. coryphæus*, resembling rather the latter in the great length of the posterior hook, which is without posterior marginal button. The proximal external angle is large and obtuse, and is continued into a prominent thick ridge. The latter divides below, the thick extremity turning inwards and ceasing; an acute ridge continuing outwards and joining the exterior acute extremity of the distal articular surface. The submeatal knob is broad and thick, and not prominent, and its extremity turns at an acute angle forwards on the inner face and forms the commencement of the great ala. The articular surface is straight crescentic with an expansion on a tuberosity on the outer face (concave of crescent). The meatal pit is sunk between the ridges surrounding, one of which is on the outer margin of the posterior hook.

The *mandible* is nearly perfect. The dentary bone bears thirteen teeth, and at the extremity is contracted in both directions, and not prolonged beyond the base of the last tooth. The ridge which descends from the cotylus along the inner face of the articular bone, is not nearly so strong as in the *H. mudgei*.

	M.
Length axis with odontoid	0.062.
Elevation neural spine of do. at middle	.046
Length third cervical (body)	.05
Diameter ball { vertical	.025
Diameter ball { horizontal	.032
Length posterior dorsal	.065
Diameter ball { vertical	.038
Diameter ball { horizontal	.05
Length basis cranii	.09
" suspensorium	.105
Elevation occipital crest above floor foramen magnum	.045
Length tooth line pterygoid	.115
" maxillary bone	.21
" premaxillary laterally	.035
Width " " at second tooth	.041
Length dentary	.245
" maxillary tooth	.03
" " " crown only	.023
" os quadratum	.077
Width " " distally	.045
Length parietal	.085
" frontal to nares (median)	.11
Width " between orbits	.077
Total length of cranium (18.75 inches)	.473

The specimen above described was found by the writer on the denuded foot of a bluff on the lower part of Fossil Spring Cañon. The posterior part of the cranium with several vertebræ were found exposed, and many

other bones, including the cranium were found only covered by the superficial washed material. Other portions were exposed on excavating the blue grey bed of the side of the spur adjoining.

The name has reference to the abbreviation of the head and jaws.

LIODON GLANDIFERUS, Cope, sp. nov.

This species is represented by portions of two individuals from localities twenty-five miles apart. These are unfortunately in each case only a cervical vertebra, but they agree in possessing such peculiarities as distinguish them widely from anything yet known to the writer.

One is an anterior, the other a posterior cervical. The articular surfaces are transversely elliptic, and completely rounded above, that is, neither truncated nor excavated for the neural canal. Their vertical axes are oblique, *i. e.*, make less than a right angle with the long axis of the centrum, and the articular surface of the ball is thus carried forward, on the upper face, to much nearer the base of the neurapophyses than usual, in the anterior vertebra nearly touching them. The ball is likewise more convex than in any other species, having a slight central prominence in the posterior vertebra. There is no annular groove round the ball. In both, the articular surface of the hypapophysis is truncate and bounded by an elevation in front, a peculiarity not observed in any of the species already described. There is no trace of zygosphen in either. In the anterior vertebra the diapophyses are nearly horizontal, the posterior portion slightly thickened and oblique. The anterior portion is thinned out and very rugose above and below, and does not continue its margin into the rim of the cup. In the second vertebra, the diapophyses are very large, vertical and with a horizontal portion rising in a curve to join the middle of the lateral margin of the cup. Neural spine narrowed upwards keeled behind.

		M.
Length centrum anterior vertebra		0.064
Diameter ball	vertical	.03
	transverse	.039
Length of posterior		.064
Diameter ball	vertical	.03
	horizontal	.043
Expanse of anterior zygapophyses		.055

The first vertebra was found by the writer at the foot of a bluff on the lower part of the Butte Creek ; the second was procured by Professor B. F. Mudge from a point one mile south-east of Sheridan near the North Fork of the Smoky River.

It is this species that I compared with the *Mosasaurus depressus*, Cope, in a report on the collection made by Professor Mudge (Amer. Philos. Soc., 1871, 168 Proceedings). The size is similar, but the form of the articular surfaces is very different.

LIODON LATISPINUS, Cope.

Proceed. Amer. Philos. Soc. 1871, p. 169.

This is a large species, nearly equaling the *L. mitchellii* in its dimensions

that is forty or fifty feet in length. The remains representing it consist of seven cervical and dorsal vertebræ, five of them being continuous and enclosed in a clay concretion.

These display the elongate character seen in *L. laevis*, etc., but the articular surfaces are transversely oval, thus resembling the *L. ictericus*. they are less depressed than in *L. perlatus* and *L. dyspelor*. The cup and ball of the penultimate cervical are a little more transverse than those of the fourth dorsal, and none of them are excavated above by the neural canal. The last cervical is strongly keeled on the middle line below, and with a short obtuse hypopophysis marking the beginning of the posterior third of the length ; the median line of the first dorsal has an obtuse ridge. There is no keel on the fourth dorsal, but the lower surface is concave in the antero-posterior direction. The diapophyses on the last two cervical aud three first dorsal vertebræ have great vertical extent ; the articular surface for the rib is not bent at right angles on the first dorsal. Neural arches and spines are well preserved in most of the specimens. There is no trace of zygantrum. The neural spines are flat, and have considerable antero-posterior extent on cervical as well as dorsal vertebræ, and are truncate above. The first dorsal bears a long strong rib.

	M.
Transverse diameter cup penultimate cervical vertebra	.051
Vertical diameter of same	.041
Length centrum fourth dorsal, without ball	.072
Vertical diameter ball	.0455
Transverse do.	.0555
Elevation front margin neural spine penultimate cervical	.088
Antero-posterior diameter do. do. do.	.05

There are smooth bands around the balls, and the surfaces of the centra are striate to these.

The depressed cups of the cervicals and anterior dorsals distinguish this species from the *L. validus*, *L. proriger* and *H. mudgei*. The same elements are much larger and more elongate than in *L. ictericus*.

It differs especially from these species of *Holcodus* and from *Liodon curtirostris* in the elongate form of the anterior dorsals ; in the latter, they are much shorter and in three of them at least, the inferior limb of the diapophysis is turned forwards to meet the rim of the cup, while this feature ceases with the last cervical in *L. latispinus*. The articular surfaces have planes at right angles to the axis of the centrum and are not prolonged above as in *L. glandiferus*. The last hypapophysis is very short, with the anterior margin transverse and elevated as in the last named species.

In size, this species is intermediate between such gigantic forms as *L. dyspelor*, and the lesser *L. curtirostris*.

The type specimens were found by Professor B. F. Mudge, one mile south-west of Sheridan near the "Gypsum Buttes."

LIODON CRASSARTUS, Cope, sp. nov.

Liodon large species near L. proriger, Cope, Proc. Am. Philos. Soc., 1871, p. 168.

This saurian, which is similar in size to the last, is represented by a series of dorsal lumbar and caudal vertebræ with some bones of the limbs.

The vertebræ are as much distinguished for their shortness, as those of *L. latispinus* are for their elongation. The articular faces are but little broader than deep, and their axes are slightly oblique. They are very slightly truncate above by the neural canal. The inferior face is somewhat concave in the longitudinal direction. The zygapophyses are stout and there are no distinct rudiments of zygospen.

The dorsal vertebræ best preserved are those in which the diapophyses reach the middle of the sides of the centra, and have no horizontal limb. They are narrow and have not extensive articular extremital surfaces.

The lumbars and anterior caudals have round articular surfaces. One of the latter with strong diapophyses but posterior, is sub-pentagonal in outline of cup. The humerus is a remarkable bone having the outline of that of *Clidastes propython*, Cope, but is very much stouter, the antero-posterior dimensions of the proximal extremity being greatly enlarged. The long diameters of the two extremities are in fact nearly at right angles, instead of in the same plane; and the outline of the proximal is subtriangular, one of the angles being prolonged into a strong deltoid crest on the outer face of the bone, which extends half its length. The inner or posterior distal angle is much produced, while the distal extremity is a flat slightly curved diamond-shaped surface. The fibula is as broad as long and three-quarters of a disc. The phalanges are stout, thick and depressed, thus differing much from those of *Liodon ictericus*. A bone which I cannot assign any other position than that of femur has a peculiar form. It is a stout bone, but more slender than the humerus. The shaft is contracted and subtrilateral in section. The extremities are flattened, expanded in directions transverse to each other, the proximal having, however, a lesser expansion, in the plane of the distal end. The former has, therefore, the form of an equilateral spherical triangle, the apex enclosing a lateral fossa, and representing probably the great trochanter. The distal extremity is a transverse and convex oval.

This bone is either ulna, femur, or tibia, judging by form alone. Its greater length as compared with the fibula, forbids its reference to the last; the trochanter-like process of the head is exceedingly unlike any examples of the second bone I have seen. Its reference to femur is confirmed by its presence with the caudal-vertebræ of a similar species from near the Missouri River, Nebraska, and its resemblance to the femur of *L. dyspelor*.

	M.
Length humerus	0.10
Proximal diameter do	.095
Distal " "	.102

	M.
Length femur	.08
Proximal diameter do	.065
Median " "	.035
Length centrum dorsal vertebra without ball	.061
Transverse diameter cup	.06
Vertical " "	.053
Length of a lumbar (total)	.055
Diameter ball do (transverse)	.06
Length caudal	.041
Depth ball do	.052
Width do do	.052

The form of the humerus is something like that of *Ichthyosaurus*.

Both this element and the femur are remarkable for their small size. They are scarcely half the dimensions of the elements of the anterior limb of *Holcodus ictericus*, and are even less than those of *L. dyspelor* in proportion to the animal's size.

It is unnecessary to compare this species with any but the *Liodon proriger*. Of this species, I unfortunately do not possess any of the limb bones, and must rely for comparison on vertebræ alone. The type specimen lacks the dorsals, hence the caudals alone remain for comparison. This shows that they are three or four times as large as the same proportions of the *L. crassartus*. In a smaller specimen of *L. proriger*, the dorsals are preserved, but so crushed as to be little available for measurements. One point besides the greater size is noticeable, their generally more elongate form, and the distinct superior emargination for the neural canal.

The remains above described were obtained by Professor B. F. Mudge, near Eagle tail, in Colorado, a few miles west of the line separating that Territory from the State of Kansas.

A series of twenty-nine caudal vertebræ with and without diapophyses, from a bluff on Butte Creek belongs perhaps to this species. The proximal specimens at least, cannot be distinguished from those of Professor Mudge's collection. The distal ones cannot readily be distinguished from the terminal ones of *L. proriger*.

Liodon proriger, Cope.

Proc. Acad. Nat. Sci., 1869, 123. Trans. Am. Philos. Soc., 1870, 202.

This is the most abundant of the large species of the Kansas chalk. The writer found a muzzle consisting of premaxillary, and portions of maxillary and dentary bones, in a spur of the lower bluffs of Butte Creek, and numerous fragments of cranium and vertebræ on a denuded tract in the same neighborhood. Both of these belonged to individuals of smaller size than the type, the opportunity of examining which I owe to Professor Agassiz. The more complete Butte Creek specimen belongs to a huge animal; the size is grandly displayed by a complete premaxillary bone with its projecting snout, and large fragments of the maxillary. These

furnish characters confirmatory of those already given as above. The vertebræ are remarkable examples of flattening under pressure, without fracture, some of them having a vertical diameter no greater than one's hand. The cervicals are less flattened and give the impression that they were not transversely elliptic. This is consistent with our knowledge of the perfect specimen, where it is as described, furnished with vertically ovate articular surfaces. In this the cup is symmetrical and not distorted, but the ball is a little compressed by pressure,

The most important addition to the knowledge of this species, furnished by the Butte Creek specimen, is the character of the quadrate bone. The external longitudinal angular ridge is very prominent and extends to the distal end. It supports a hook-like prolongation of the proximal articular surface, almost as large a one as in *Clidastes propython* and more narrowed. The ridge is so prominent as to create a wider face or surface, behind the basis of the great ala than exists between the latter and the edge of the articular meatus. This basis is quite convex outward and embraces a relatively smaller space than in other Pythonomorpha. A section of the bone at the meatus is subtrilateral with a notch behind. The distal articular surface is prolonged below the origin of the great ala, and receives the keeled termination of the external ridge.

	M.
Total length quadrate	0.153
Length from superior to inferior origin of great ala	.08
Length external angle from bases of ala	.052

The two usual ridges pass inward and downwards from the meatal knob.

The above quadrates are flattened from within outwardly by pressure.

A portion of the palatine bone, supporting these teeth, displays the characters of the type, viz.: the inner face vertical and deeper than the outer, and forming a strong parapet of bone on the superior or toothless aspect. The outer face a little expanded laterally : the bases of the teeth exposed.

It is proper to add, that the locality ascribed to the type specimen "near Fort Hays, Kansas," which was given me on inquiry, is probably erroneous, Fort Wallace being the point intended.

LIODON DYSPELOR, Cope.

Proced. Amer. Philos, Soc., 1870, 574; 1871, 168, 172.

This large reptile was first described from specimens sent to the Smithsonian Institution from New Mexico. Professor Mudge subsequently obtained it in Kansas, and on my late expedition I had the good fortune to procure a large portion of another, on a sloping bluff on Butte Creek, fourteen miles south of Fort Wallace. This specimen is one of the most instructive which has yet been discovered, including as it does fifty vertebræ from all parts of the column, a large part of the cranium with teeth and both quadrate bones; the scapular arch complete, except lack of coracoid on one side, both humeri, radius and numerous phalanges of

fore limb; the pelvic arch complete with one hind limb complete to tarsus, with phalanges. The premaxillary is wanting, but the adjacent suture of the maxillary remains.

The *fronto-nasal septum* is convex in transverse section. The *maxillary* bone is much attenuated anteriorly, and supports thirteen teeth. The *ramus mandibuli* is high and slender; the angle is quite produced, and the median articulation indicates considerable mobility. The *palatine* bones are narrower than in any of the species previously described. They are deeply notched for union with the pterygoids, and the superior posterior process terminates in an acute cone. In front of the articulation, the bone is a vertical plate slightly concave on the inner side; the anterior half is subquadrate in section, the outer face subvertical, the inner, regularly rounded. The inferior surface is marked with a groove which passes from the inner side to the outer. The portion on the outer side of this groove, is on the distal third of the bone produced downwards into a prominent keel or ridge. The anterior extremity is an acute point. Each bone bears eleven teeth, all of which have the external faces of their roots exposed. The bones are curved outwardly from the fourth tooth from behind; opposite the sixth there is longitudinal concavity on the inner face.

The occipital region and suspensoria are not present, but both, *quadrates* were found perfectly preserved excepting the thin ala. They present marked characters, being most nearly allied to those of *L. proriger* and *L. validus*. The proximal articular surface exhibits an obliquity in the transverse direction. It presents a large external angle which instead of being nearly at right angles to the axis of the main portion of the surface, is nearly in the same line. The decurved posterior hook is very short. The distal articular surface has, like that of other *Liodons*, a small transverse extent, and is divided by a concavity into two tuberosities. The outer of these receives at its angle the prominent narrow portion of the external ridge, which extends from the external proximal angle. The prominence of this ridge is greater than in any other species except *L. proriger;* it is acute throughout its length and has a gentle sigmoid flexure. The basis of the great ala includes a smaller area than usual and is continuous with a prominent narrow ridge which proceeds from inside the metal crest. The metal crest takes the place of the "knob" in such *Mesasauri* as *M. dekayi*, it projects strongly backwards and outwards as an angle of two ridges; the inferior being acute and curved and terminating above the middle of the distal condyles. The meatal pit is not concealed between ridges, but is external; its form is peculiar, being a narrow oval, three times as long as wide, directed downwards and forwards. Thus the characters of this element are well marked among those pertaining to the other species.

The *teeth* are not much compressed, and have a cutting angle on the anterior and posterior margins, which separate nearly equal faces.

The *vertebral centra* change in form from the anterior to the posterior

regions. The ball of the axis is round, those of the vertebræ early succeeding are moderately depressed. The balls of the dorsals are transverse elliptic with a slight concavity for the neural canal; the plane a little oblique to that of the long axis. The centra are more depressed posteriorly where the balls of the dorsals present rounded lateral *angles*. On the lumbars preceding the caudals, the base of the neural canal becomes more elevated, and the articular faces assume a slightly pentagonal outline. This form continues as far as our specimens of caudals extend. On three lumbars, the centra present two longitudinal angular ridges below, at whose posterior ends the chevron articular surfaces appear on the first caudals. All present an incised marginal groove to the ball. The surface, especially the inferior, is strongly rugose up to this groove, especially on the dorsals.

The *axis* is much shorter than in any other species here noted, where known. The neural spine has a very oblique superior margin and is expanded behind. The diapophyses are narrow, and continued as vertical plates to the inferior face of the centrum at its anterior margin. The diapophyses of the other cervicals have the usual horizontal limb, which is, however, shorter than the vertical. In the anterior dorsals, they are directed more obliquely upwards and are longer. These, and all other dorsals, maintain a connection between the rim of the cup, and the anterior basis of the diapophysis by a smooth area apparently capped by cartilage in life, as exists in *L. curtirostris*. As we pass posteriorly these processes descend, and become narrower, until finally they thin out and lengthen into the ribless diapophysis of the lumbars. Those of the caudals are long and subcylindric. Their extremities are deeply striate grooved. The neural spines of all the vertebræ are longitudinaly striate keeled. The zygapophyses are remarkable for their narrow form and surfaces. The *atlas* is shorter on the outer, and longer on the inner face than in *L. validus*. This is caused by the fact that the posterior articular face is not transverse, but very oblique, and instead of being vertical and narrow, is obliquely longitudinal in its long axis. It is separated from the inner face by a wide rugose grodve behind; its lower edge sends a keel downwards. There is no process at the thinned infero-anterior angle.

The *scapular arch* was small especially the scapula, which is absolutely smaller than that of the *Holcodus ictericus*, a very much smaller reptile. The posterior margin is thickened, the anterior thinner, and less elevated. The superior is arched upwards and backwards. The general form is less oblique than in *L. ictericus*. The *coracoid* is twice as large, and is flat and thin. Its inner margin is regularly convex, the posterior concave and thin, the anterior thickened. The foramen is present.

The *humerus* is different in form from that observed in *L. crassartus*, *L. ictericus*, *Clidastes*, *etc.* It is relatively less expanded proximally and especially distally; there is but one deltoid crest, which is proximal and near one extremity of the articular surface, and disappears into the gene-

ral plane above the middle of the shaft. The general form is flat, partly due to pressure. The distal extremity is but little convex and displays the terminal muscular insertions but little produced. Near the inferior end there is one external expansion for articulation with the ulna.

The *radius* is lost. The ulna, or a bone which is like that regarded as such in several species described by me, has the extremities in different planes which cross each other obliquely. The proximal is triangular and very wide, too wide for the humeri in their present state. It is also too long, leaving but little space for a radius. The distal extremity is as expanded, but much narrower, and presents too articular surfaces, a large and wide, and a narrow, connected by a wide isthmus. The bone was taken out near a humerus, but not in position.

The pelvic arch, as above remarked, was found perfect, and with all the elements in place, with a femur with the head in relation to the acetabulum. The articular extremities are somewhat depressed and do not precisely fit. The *ilium* is a straight flattened bone, dilated moderately at the articular extremity. It is coarsely rugose striate at both extremities. The *ischium* is a longer bone than the ilium, is more slender, and more expanded at the articular extremity, where it is also thickened. The shaft is curved so as to be sub-horizontal in position; it shows no trace of union with its mate. The *pubis* is a broader bone, with the axis transverse to that of the body, and sigmoidally curved, first slightly forward then gently backwards. The common suture is about as wide as the proximal extremity. The posterior margin is somewhat thickened; the anterior is produced into a process directed forwards, which is the homologue of that seen in the *Testudinata*. It is connected with the distal end by a thin concave margin.

The *femur* is rather more slender than the humerus; the distal extremity is about as much dilated, the head less so. The great trochanter is a thick convex ridge with a truncate discoidal articular extremity, which is nearly separated from the head by a groove. Both extremities are moderately convex. The *fibula* is similar to that of other species in its broad, three-quarters discoidal form. Both articular surfaces are strongly convex and are continued on the inner side on the thinned inner border. The external margin is thickened and deeply concave, and without tuberosity. The *tibia* is a more slender element with sub-cylindric shaft and much expanded extremities. The proximal is oval and is continued as a narrow ridge on the inner side, for contact with the corresponding ridge of the fibula. The distal extremity is an equilateral spherical triangle, of which the inner angle is on a different plane from the remainder.

The *phalanges* are slender with cylindric shafts and expanded extremities, which support oval articular surfaces. Those of the two extremities appear to be similar. The distal ones are extremely small and flat, with expanded extremities.

Of *doubtful bones* may be mentioned two with flat expanded distal extremity and thick proximal, bearing an oval articular surface, with an

angulate extremity which terminates in a thin edge. The form is like that of a narrowed radius of *L. ictericus*, but it is much too short for the ulna. As it was found with the scapula, it is probably a portion of the fore limb, and hence may be a metacarpal. A somewhat similar but narrower bone may be metatarsal. A piece which is probably the free *hypopophysis* of the atlas, is a transversely elliptic piece with an oblique smooth articular face at one end. The posterior face rugose, the inferior with a flat truncate process directed downwards and backwards. If correctly identified, its great peculiarity consists in its thinness anteroposteriorly, and the large process.

In comparing this species with the *L. proriger*, its nearest ally, I have already observed the difference in the form of the articular surfaces of the cervical vertebræ, which is in that species vertically oval; the present, transversely so. The comparison is made between posterior cervicals of both, which in *L. dyspelor* are less depressed than the others. As it is possible that the form in the type example of *L. proriger* may be slightly affected by pressure, I compare other points. Thus the palatine bones are more slender anteriorly, and the outer edge descends lowest in a ridge; in *L. proriger* inner is produced downwards as a longitudinal rib. In this species there are eleven teeth; in that one, nine. The quadrate bone of *L. proriger* presents a longer external angle, and more prominent external ridge, with smaller space enclosed by the bases of the greater ala. My statement in a published letter to Professor Lesley, that the ends of the mandibles were acute, thus differing from *L. proriger*, is an error, due to my having mistaken the palatines for the dentaries on a cursory examination in the field. The posterior extremity of these bones in *L. proriger* is unknown.

The only species whose dorsal vertebræ are known to resemble in the stoutness of their form those of *L. dyspelor*, is *L. crassartus;* the manifold differences of the latter will be at once discovered on reading the description already given.

Measurements.

	M.
Atlas length inner articular face	0.065
" " posterior " "	.054
" depth " " "	.037
Axis length at middle of side	.075
" depth anteriorly	.081
" elevation neural spine	.075
" width " " (plane)	.045
" diameter ball { vertical	.07
" diameter ball { horizontal	.07
Cervical " " { vertical	.066
Cervical " " { horizontal	.076
" length	.09
Anterior dorsal, diameter ball { vertical	.065
Anterior dorsal, diameter ball { horizontal	.087

Measurements.	M.
Anterior dorsal, length below (with ball)	.10
" " " diapophysis	.047
" " depth "	.04
Posterior " length centrum	.097
" " diameter ball { vertical	.076
" " diameter ball { horizontal	.105
" " height neural spine (of another)	.12
Lumbar length centrum	.09
" diameter ball { vertical	.073
" diameter ball { horizontal	.09
" length diapophysis	.096
Caudal (anterior) length centrum	.073
" " depth ball { horizontal	.085
" " depth ball { vertical	.075
" " length diapophysis	.12
" (posterior) " centrum	.067
" " " diapophysis	.10
Caudal (posterior) height neural spine	.087
" " diameter ball { vertical	.08
" " diameter ball { horizontal	.084
Maxillary bone, length	.65
" length basis of two teeth (largest)	.09
Mandible, depth behind cotylus	.11
" length " "	.11
Width nasal septum	.021
Length palatine on tooth line	.38
Depth " at third tooth from front	.039
Quadrate length	.15
" " external angle	.029
" width face from meatus to external ridge	.029
" " area of basis of ala	.04
" " at condyles	.07
Scapula, height (axial)	.12
" width	.183
Coracoid, "	.187
" length	.20
" thickness at cotylus	.027
Humerus, length	.189
" proximal width	.12
" distal "	.127
Ulna, length	.179
" width { proximal	.115
" width { distal	.116
" thickness proximally	.06
Ilium, length	.245
" width { proximal	.039
" width { distal	.178

Ischium, length on curve			.350
"	width	proximal	.018
		distal	.087
Pubis, length (straight)			.195
"	"	to anterior process (axial)	.125
"	width	proximal	.085
		distal	.075
Femur, length			.185
"	width	proximal	.093
		median	.064
		distal	.130
Fibula, length			.116
"	width	proximal	.100
		distal	.118
"	proximal thickness		.052
"	median width		.08
Tibia, length			.103
"	width	proximal	.045
		median	.025
		distal	.052
"	thickness	proximal	.042
		distal	.030
Phalange (posterior), length			.08
"	terminal	"	.015
Estimated length, cranium (five feet)			1.510
"	total length		75 feet.

This specimen does not appear to be quite as large as the type, which came from Fort McRae, New Mexico. The diameters of the vertebral centra appear to be larger in proportion to the length of the cranium than in the *Mosasaurus dekayi*, hence probably the body had a greater diameter. In estimating its length, reference is had to the relations in size of the caudal vertebræ of the type of *L. proriger* and to the caudal series of a small *Liodon* found on the bluffs of Butte Creek. The caudal vertebræ are quite similar to those of the former; in the latter, a series of thirty centra exhibit very little diminution in size. On such a basis the length would be about seventy-five feet.

Portions of a second individual of this species or of *L. proriger*, were found on Fox Cañon. They belonged to a larger animal, one equal to the New Mexican first described. Professor Mudge has fragments of still larger specimens.

The principal specimens above described was excavated from a chalk bluff. Fragments of the jaws were seen lying on the slope, and other portions entered the shale. On being followed, a part of the cranium was taken from beneath the roots of a bush, and the vertebræ and limb bones were found further in. The vertebral series extended parallel with the outcrop of the beds, and finally turned into the hill and was followed so far as time would permit. It was abandoned at the anterior caudal vertebræ, for more favorable circumstances, or a more persevering excavator.

The outcrop of the stratum was light yellow. The concealed part of the bed was bluish. Yellow chalk left on the specimens in thin layers became white or nearly so. The yellow and blue strata are definitely related in most localities, the former being the superior, but in others they passed into each other on the same horizon.

Stated Meeting, January 5th, 1872.

Present 14 members.

JOHN C. CRESSON, Vice-President, in the chair.

Letters of acknowledgment were received from Professor Lewis Strohmeyer, Dec. 8th, 1870 (81, 82, Proc. A.P.S.), Boston Public Library, Dec. 19, 1871, R. Saxon Society, Feb. 8, and July 8, 1871 (84, 85, Trans., Vol. XIV., i. ii.), Natural History Society, Bremen, Aug. 29, 1871 (83, 84, 85) Professor Frerichs, Feb. 8, 1871 (83, 84, 85), R. Bavarian Academy, Sept. 18, 1871 (83, 84, 85, XIV., i. ii.), R. Observatory, Munich, Aug. 14, 1871 (83, 84, 85), Imperial Russian P. C. Observatory, March 13, 1871 (62, 73, 74, 78, 81, 82, Trans. Vols. I. to IX., and XIII., iii.), Bordeaux Society of Sciences, Nov. 16, 1871 (82 to 85), R. Academy, Berlin, Aug. 9, 1871 (83, 84, 85, XII. i., XIV. i. ii.), Imperial Observatory, Prag., Aug. 16, 1871 (83, 84, 85, XIV. i. ii.)

Letters of envoy were received from the Chief of U. S. Engineers, Washington, Dec. 21, 1871, and from the Imperial P. C. Observatory, St. Petersburg, Aug. 16, 1871.

Donations for the Library were announced from the publishers of the Flora Batava, and Dr. Schotel, P. C. Observatory, St. Petersburg, Academy and Observatory at Munich, Societies at Bonn and Bordeaux, Geographical Society and School of Mines at Paris, Mr. Stephenson, M. P. Newcastle-on-Tyne, London Nature, R. Astronomical Society, the Natural History Society at Bagota, S. A., the Massachusetts Historical Society, Boston Library, Old and New, Silliman's Journal,

Chief of U. S. Corps of Engineers and Colonel Williamson, the U. S. Coast Survey, Dr. Genth, Dr. Hayden, Mr. Thos. Tennant of San Francisco and Mr. Stephen Olney of Providence, R. I.

Mr. Chase for the Committee on the Paper on Knights' Tours, reported progress.

The death of Robert S. Breckinridge, a member of this Society, at Danville, Ky., on the 26th Dec., 1871, aged 71 years, was announced by the Secretary.

The death of Professor Franz Bopp at Berlin, was announced by letter.

Mr. Eli K. Price read a paper on some Phases of Modern Philosophy, the discussion following which was postponed to the next meeting.

The Chairman of the Finance Committee presented its Annual Report, and, on motion, the appropriations recommended therein for the ensuing year were passed.

Mr. Lesley was nominated Librarian for the ensuing year.

Pending nominations 679 to 688, and new nomination No. 689 were read.

The Reports of the Judges and Clerks of the Annual Election was read, and the following named persons were reported officers for the ensuing year:

President, George B. Wood.

Vice-Presidents, John C. Cresson, Isaac Lea, Frederick Fraley.

Secretaries, Charles B. Trego, E. O. Kendall, John L. Le Conte, J. P. Lesley.

Curators, Joseph Carson, Elias Durand, Hector Tyndale.

Councillors to serve three years, Daniel R. Goodwin, Eli K. Price, W. S. W. Rushenberger, Henry Winsor.

And the meeting was adjourned.

SOME PHASES OF MODERN PHILOSOPHY.

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"I am a brother to dragons, and a companion to owls." So Job was constrained to say in the hour of his great afflictions: so others now say induced only by speculative philosophy.

The tendency of much of the modern natural and physical philosophy is to degrade our humanity, and to dispense with the belief of a Creator. Delvers in a special field are not content to exhibit what they find for the use of those who are farther advanced and prepared to take a broader survey from a more elevated height; but they theorize and make their inductions from facts too few and inadequate for the conclusions drawn. The result cannot be truth, but error. Theories so built are raised to be quickly thrown down. They are the least fit to survive in the struggles of science.

All carefully observed and true facts philosophy must receive and register for her legitimate uses. But if philosophers be not certain of the truth of facts, and have not all that are requisite for truthful conclusions, they violate the fundamental canon of philosophizing: they necessarily land in error, and bring reproach and ridicule upon philosophers and philosophy. Much labor and expense of printing are wasted, while students are misled, science is obstructed, and it is made necessary for the lovers of truth in the next to correct the errors of this generation.

I. The first subject to which I would now ask your attention is that of Spontaneous Generation. Dr. Erasmus Darwin had, at the close of the last century, ascribed to Nature the power of spontaneous generation; and thus concludes:

> "Hence, without parent, by spontaneous birth,
> Rise the first specs of animated earth;
> From Nature's womb the plant or insect swims,
> And buds or breathes, with microscopic limbs."
> [*The Temple of Nature*].
>
> "Organic life beneath the shoreless waves
> Was born, and nurs'd in Ocean's pearly caves."—[*Ibid*].

But he had the imagination of the poet; and his imagination sometimes assumed his facts.

There is a present effort to go a step further, and prove that life can be produced by man from matter, without propagation from other life; and if you add to this the theory of evolution, by which all complicated life is derived from first simple forms, we have two theories, which, taken together, will account for all life, without a Creator. There are, however, certain things, like perpetual motion, so contrary to nature, as not to be credible. The fact of spontaneous generation has not yet been satisfac-

torily proved; and, it is believed by those best enabled to form a correct opinion, will never be proved. The life produced by the experimenter is, no doubt, but a process of developing seeds or spores, or of hatching eggs, that exist invisibly in the atmosphere, and within the tube used in the experiment, and from which they had not been perfectly expelled. And well it is that life is not, and cannot be, spontaneous, for, if noxious, and no law of reproduction restrained the increase, there could then be no hope of its effectual extermination; but, if depending upon parental production, when you destroy the parents, you destroy the pestiferous succession. This was the basis of the confidence of Pasteur in his successful researches and efforts to find out and destroy the parasite that destroyed the silk-worms in France.

It is also the hope of mankind to escape contagious diseases, that proceed from germs that ever re-produce the same disease, be it small-pox, scarlet fever, or cholera, or other plague, for the spread of which the corrupted air becomes the fitting propagating medium.

If new generation were possible, there would result confusion; it should be bound by no rule if not produced in the course of nature; there could never then be scientific classification into genera and species, and all order and harmony would become impossible. It is a necessary ordination of the Author of nature that generation should come from a living parentage, and that parents should ever produce their like. Such we know to be nature's procedure. Such process must proceed by law, that the progeny shall be like their parents, and of different sexes, and such law and such sure observance of law, imply an intelligent Creator, who never ceases to watch over his creation. Life has been on the earth in countless forms, and in infinite multitudes, through nearly all the geological formations from water deposition, and ever since; but none of that life has been thought to be spontaneous, except in the imagination of the poet, or of the fanciful theorist. All except the first of each kind, for which we infer a Creator, came by generation, from parental germs and ova, as we must believe from observation; or by fission, which but subdivides life and thereby multiplies it. It is, however, now announced in this age of great discoveries that man can produce life where no life was.

Dr. Bastian has made numerous experiments and written a book on "The Modes of Origin of Lowest Organisms," and believes that he has produced them *de novo*, "independently of pre-existing living matter." But his book makes necessary admissions that must go far, if not quite, to destroy his theory. All the living organisms which he produced had been before known as existing in the course of nature, and had been named. They are called *Bacteria*, *Torulæ*, *Vibrones*, *Leptothrix*. But why were these, and but these, produced, unless they had a parentage through germs containing life? Why not something new? Certainly these were not new creations of life, but something re-produced that had before their given law; and it is easier for the scientific mind to believe that the parental germs had not been removed by the experimenter, than that he had witnessed a new production of life. This view is well con-

firmed by this statement of the author: "*Bacteria, Torulæ*, or other living things which may have been evolved *de novo*, when so evolved, multiply and reproduce just as freely as organisms that have been derived from parents," p. 3. Now what living thing or creature in all nature ever has propagated, or can propagate its kind, except it has inherited that power from a living parent? From the beginning it has been that the grass, or herb, and fruit tree, "whose seed is in itself," has yielded "fruit after his kind;" and the living creatures have "brought forth abundantly after their kind," and only so have they replenished the earth.

Professor Tyndall's article "Dust and Disease," is commended to the student who would learn how all pervading in the air of London are the seeds of life and of disease. (*Fragments of Science*, 277.)—Stating the result of experiments, he says, "The whole of the visible particles floating in the air of London rooms being thus proved to be of organic origin." (p. 279,) "The air of our London rooms is loaded with this organic dust; nor is the country air free from its presence." (p. 285.) And hence, no doubt, the ova were hatched by Dr. Bastian, or the germs made to grow.

Sir William Thomson in his recent address, as President of the British Association, (Nature, August 3, 1871,) adds his authority to that of the opponents of spontaneous generation. "Science brings a vast mass of inductive evidence against this hypothesis of spontaneous generation, as you have heard from my predecessor, (Professor Huxley,) in the presidential chair. Careful enough scrutiny has, in every case, up to the present day, discovered life as antecedent to life. Dead matter cannot become living without coming under the influence of matter previously alive. This seems to me as sure a teaching of science as the law of gravitation." * * * "I confess to being deeply impressed by the evidence put before us by Professor Huxley, and I am ready to adopt, as an article of scientific faith, true through all space and all time, that life proceeds from life, and nothing but life." Yet he, so true and wise in this induction, did not close that same address without falling into an egregious blunder, eliciting instant dissent and derisive laughter, followed by the universal condemnation of the scientific press. He too would dispense with a Creator, at least, on this planet, for he made the suggestion that the first life came to our world by a falling Aerolite, though it came fused by heat! But that was only to transfer creation to another planet. This suggestion of course committed the learned President to the extremes of the evolutionary theory, was to say that from such life as could be borne hither by an aerolite all other life on earth has come and been developed upwards to man. Of this theory let us next speak, but first pausing to declare our faith that life came only from God, and by Him alone is ever protected and preserved.

II. The theory of evolution as announced, seems to have been carried to an extravagant extreme. Its agencies are chiefly two: natural selection, and sexual selection. The life that is best fitted to endure will live the longest; and the weakest will soonest perish; and that which man takes best care of and most propagates is most likely to live in perpetuity,

while that which he destroys, because hurtful, is most likely to perish; and this is natural selection, and to a limited extent, it is obvious to all. The sexual selection is that which the male or female makes when mating. The latter influence can have no place in the vegetable kingdom, for in it there is no will to exert selection; and there is very little of it, indeed, below man in the animal kingdom; for what female is there in it, unrestrained by man that finds not her sufficing mate, be she beautiful or plain? Nature is not checked in her purpose of multiplication, when free, for want of masculine co-operation, for it superabounds. The seeds of life are always superabundant. All the fanciful writing upon this subject, the motives for the mating of birds and quadrupeds, by the attractions of symmetry and beauty of plumage or color, seem quite unimportant: where all mate sexual selection effects nothing. The real check to increase comes from want of food, severity of climate, disease, and enemies, which spare not symmetry or beauty, and not from any failure to be selected.

Nothing is more certain, however, than that as far as man exercises a dominion, by the culture of plants and breeding of animals, he does greatly increase some in numbers and quality, and he diminishes others. He practices great partially. The flowers and fruits, and vegetables and grains that best please and nourish him, he will most cultivate, and destroy all things that most obstruct their growth. The birds, fowls and animals that are most useful and please him best, he also breeds and greatly multiplies, and he destroys their enemies. The cattle on a thousand hills are justly for its use, because they are bred and fed by himself to do his labor and be his food; and his care and skill make it sure that they shall be the best fitted for his purposes. And this is also called natural selection; although it is the result of man's skill exerted upon nature and the laws that govern nature. Its effect is great, but is not unlimited, and is subject to reversal when man ceases to exert his care and skill.

There is truly a law of nature in propagation, that each species, and each pair of individuals shall produce a progeny like themselves. Man selects the parental pairs of the qualities he desires, and his hopes are seldom disappointed. He repeats the process until he arrives at the highest perfection in view that is attainable; hence our fleet race horses, our strong draught horses; and also our finest breeds of cattle and sheep, selected with a view to their qualities for milking, clip of wool, or beef, or mutton. Thus the wild animals are inestimately improved! And so with these and other purposes, and the large indulgence of a capricious fancy, have pigeons, poultry and dogs been improved, or greatly changed in their varieties, until it is made a question whether such variations have not been carried to the length of making new species. The success of such proceeding has been made the basis of a theory so extreme, that it at once threatens to destroy the classifications of science, and the religious faiths of mankind.

It is, indeed, also true, that the like inheritable qualities exist in the

human species, and if men and women were as careful in mating, as men are when breeding their horses, cattle, sheep and pigs, to consider whether those they select are well endowed with bodily and mental perfections, the physical and moral qualities of families might also be alike improved; though the unattractive among mankind would still not be disappointed in the opportunity of mating, if they have the means of livelihood or the ability to win it; the want of which constitutes the most serious check to matrimony and the increase of population. But mankind are neither so careful in selecting what shall be the qualities of the father or mother of their children, as farmers are of the pedigree of their stock; nor are men or women so careful of their own training and feeding, and the preservation of their health and beauty by temperance and exercise, so that they are more derelict in duty to themselves than to their animals, and the race has not been improved as it should have been. Yet, it may well be questioned whether the human race is improved in the aggregate by sexual selection, since generally men and women do marry, and since the women who fail to marry from the absence of personal attraction, are probably outnumbered by those whose personal attractions, combined with their moral weakness, causes them to become the victims of "the social evil," of which sterility is one of the retributions. Yet the race, is undergoing a constant physical and moral improvement; but it proceeds from Christian civilization; a civilization that does believe in an ever-living watchful Creator, and that would suffer terrible relapse, if that belief were lost. This is said on the proof of boundless facts.

If we consider the conditions of all life as found in nature, before man began to reduce it to his dominion, and the methods of his procedure and its results, just as the evolutionists have described, we shall be able to value their scientific significance, and to test the truth of the theory raised upon the narrated facts. Darwin in selecting his illustrations says, as to dogs and their various breeds, "that some small part of the difference is due to their having descended from distinct species;" "In regard to sheep and goats I can form no decided opinion." The humped Indian cattle have a different origin from the European cattle, which are supposed "to have had two or three wild progenitors." With respect to horses he says, "I am doubtfully inclined to believe, in opposition to several authors, that all the races belong to the same species." As to fowls, "it appears to me almost certain that all are descendants of the wild Indian fowl." As to ducks and rabbits, "the evidence is clear that they are all descended from the common wild duck and rabbit." "Great as the differences are between the breeds of pigeons, I am fully convinced that the common opinion of naturalists is correct, namely, that all are descended from the rock pigeons."—Darwin on Origin of Species, p. 30 to 35. Now what is the import of this? First, that by nature, or the Cause of nature, when or wherever man has not interfered to modify, the demarcations of species have been well and persistently defined. Through all the geological ages and downward to the time present, the operations of nature, when let alone were and are simple and true, without tendency to variations, or

acting under a power that ever corrected them. The wild progenitors were without variations; in that state new species were not formed by process of variations; nor was there transition by gradual change from a lower to higher species; nor do geology and history afford the proof of such change, and the theory depends upon conjecture asserted against the truth of our observations and just inferences, that nature has always operated as we see her now do in those vast domains of ocean, mountain and forest, that lie beyond the interference of man. With the living life of the oceans man can do nothing except slightly to diminish the numbers of whales and fishes, and there the processes of nature go on without change; and so has it ever been in the deep recesses of forest and mountains yet unpenetrated by man, or, if the scientific adventurer has penetrated, it has been to leave no trace of his power there. It has been man only that has disturbed the truthful proceedings of nature; modified them for his own benefit.

Again, it is to be considered that all that man has done, he must forever continue to do, otherwise nature will re-assert her dominion, and undo all that man had done to mar, or pervert, or perfect her works; and she will restore them to their pristine simplicity. This we know she is always doing, from abundant observations; she makes hybrids unfruitful; her ban forbids changes that shall endure; the seedsman and gardener ever watch their choice crops, fruits, vegetables and esculents, and must do so, for they know well that nature ever resumes the attempt to "cry back;" that is, to return to that condition from which the skill of man has forced her to meet his own wants, or to please his fancy. Who can reasonably doubt that if man was to cease to be on the earth that his seeds, and esculents, fruits, and all domesticated animals would in process of time, return to their natural conditions? Human care and culture and provisions ceasing, the antecedent causes of nature would again come into exclusive operation; and by her own truthful observance of cause and effect, the ancient condition of vegetable and animal life would be restored as they were on the face of the earth. Without his stores of provision and provender and shelter, a single severe winter would cut his before housed and sheltered vegetables and animals, by frost or starvation, down to about the thirty-seventh degree of latitude; and half the variations that have grown up under the training hand of man might perish at a blow. What man has achieved over living nature may, therefore, be considered as an artificial work of but temporary endurance. Darwin fully admits this when he says, "Natural selection is a power incessantly ready for action, and is as immeasurably superior to man's feeble efforts as the works of nature are superior to art." Ib. p. 70. When let alone she elects to return to her original conditions.

Of the variation produced by selection in breeding and the better care of animals, Darwin says, "the key is man's power of accumulative selection: Nature gives successive variations; man adds them up in certain directions useful to him. In this sense he may be said to have made for himself useful breeds." Origin of Species, 40. But what does nature do

when man does not seize upon the offered variations to make them inheritable, by bringing together two of different sexes with the like variations to become parents of a common like progeny, and afterwards preserving only those which most strongly shew the desired variation? The variation from one parent only would quickly fade out into the normal character. Those having variations, Darwin says, "would during the first and succeeding generations cross with the ordinary form, and then they would almost inevitably lose their abnormal character." Ib. 53. Nature, of herself, does not interpose to seize upon and continue the occasionally occuring variation. She does not select a mate of like variation; nor does she develop it to a higher perfection by training or better feeding, and make it the special centre of a favored propagation. Natural selection, unaided by man, must, therefore be of very limited influence, if any, towards establishing a change, whether to be called a variation or a species; while the change that is wrought by man, would, without his continuing maintenance, revert to its normal condition much more rapidly than it was formed. Again variations left only to nature's care, must be such as give increase of strength, otherwise they will die out from weakness as all monsters do, or breed out to the normal condition. Ib. 90, 108. The varieties of pigeons have been the products of man's care for thousands of years; but not one-half the eggs of the best short-beaked tumbler-pigeons would be hatched without his aid to break the shell. Ib. 38, 90. This shews them degenerate; a pampered and failing aristocracy; who, left to themselves, in a state of nature, would quickly die out.

And what is the result of the selection of nature even when most assisted by man? Has it produced any new species? For more than three thousand years before Christ, and ever since, there have been pigeon fanciers who have taken infinite pains in their breeding. Ib. 38. Darwin says, "the diversity of the breeds is something astonishing." "A score of pigeons might be chosen, which, if shown to an ornithologist, and he were told they were wild birds, would certainly be ranked by him as well defined species." Ib. 34. Yet are they such? Darwin says, "the hybrids or mongrels from all the domestic breeds of pigeons are perfectly fertile. I can state this from my own observations, purposely made, on the most distinct breeeds. Now it is difficult, perhaps impossible, to bring forward one case of the hybrid offspring of two animals *clearly distinct*, being themselves perfectly fertile," p. 37. Now, if there were a possibility for nature and man together to create new species, it should have been in the instance of the long and general experiment with pigeons. It has at most amounted to producing varieties, in shape and exterior plumage and appearances, while by the truest test of inter-breeding the nature of the creature is essentially unchanged. It is probable that the truth is the same as to dogs, horses, European cattle and fowls, except as disparity in size has rendered the same test of inter-generation to a large extent, impracticable. Surely, then, that law which the Creator has so emphatically imposed upon His creation, He has not himself vio-

lated, in carrying on all His living creation from simple to higher forms through infinite processes of generation. He who has forbidden the confounding of nearly allied species, cannot be taken to have carried on the processes of generation, in violation of the ban against the confusion of species, and in disregard of all the classifications science has adopted from the study of creation, only the better to describe and understand that creation. On the contrary, it is to be taken that generation has no part in the work of creation; but has only her assigned duty, under regulative laws, to propagate creatures of the same species, of two sexes, to reproduce a progeny like unto themselves. All that we can see and know of creation brings us to such conclusion. To create is one thing, and to propagate in the parental likeness another. The propagator but fulfills an assigned instinct that is essentially imperative, except as man is self-restrained by over-ruling moral considerations. His function is a very limited one. The inception of new life, its gestation and growth, and the measure of that growth are the work of that Higher Life or Being, that is, the Giver of all life, as we must logically infer; for every effect must have its adequate Cause.

The great distinctions of classes, orders, genera and species, as the proofs stand in geology, history, monuments and living nature, have ever remained unchanged and unobliterated; while variations within species, have been permitted for obviously good uses to man. The mules that he breeds do him good service, but mules are not permitted to breed mules. A theory that would permit a varying generation to thwart this grand order of life, and that would traverse all these classes, orders, genera and species by violations of the ban we know to forbid hybrids to breed, we may simply set down as contrary to nature and impossible, and such theory demands the clearest and most indubitable proofs, none of which have been adduced.

The theory is wholly illogical and inherently inconsistent with itself. The whole drift of the theory is to make generation build up all created life, with one or a few exceptions, without a Creator. But why any exception? Only that there shall be a starting point in life; that there shall be an incipient generator in this mighty process. But this earliest life must have had a Creator, and the capacity to generate life through all kinds must have come from a Creator; yet this theory demands none, at the beginning, or in any stage of progression, but it obviously proceeds upon the ground that generation will suffice for all life, and that life needs no Creator. Yet there is an overruling power, without which generation could not proceed, without whom there would be no ban against confusion, and without whom the required difference of sex would not come into being in the requisite proportion. The reasonable inference to be made is, that as a Creator was required for the first life demanded by the Darwinian theory, and for all its processes of generation, and the after preservation of all creatures born, the same Creator would himself create all the creatures that share his protection, in all their various species, and do so as the world was prepared for them, and was of the

temperature and had the food they required. The first creatures had a delegated power of generation; but nothing in nature has shown that they had a mission to carry on creation to higher levels either of physical structure, or moral excellence, or of intellectual power.

The whole theory is built upon chance variations from the normal course of nature, occurring at very long intervals of time. It is, therefore, presumably, not the method by which the Creator has built up creation, from one or a few of simplest forms of life, into all the elaborate classification in which we now behold it. Thus, Darwin says, "Natural selection acts only by taking advantage of slight successive variations; she can never take a sudden leap, but must advance by short and sure, though slow, steps." Ib. 190. "New variations are very slowly formed, for variation is a slow process, and natural selection can do nothing until individual differences or variations occur, and until a place in the natural polity of the country can be better filled by some modification of some one or more of its inhabitants." Ib. 171. We have seen that the help that man can give to promote such variations is very limited, and that what he effects would soon relapse without his continuing maintenance, and remain but a variety, and result in no new species; what else but nature, then, when man is not co-operating, is to "take advantage of the slight successive variations?" And what does she do? If but one parent has the variation it will very soon run out in the generative process. This Mr. Darwin readily admits, and candidly stands corrected by the North British Review, while monster variations seldom live any length of time. Ib. 93. Thus the aberrations of nature are so few and far between, and so soon to disappear, as to afford no adequate ground for the change of any species, much less suffice to produce all the classes, orders, genera, and species, into which science has arranged all living things, from one or a few primary simple types. Nature is, indeed, slow to make enduring changes, but quick to correct her errors. If jostled in her processes, she does not make the imperfect product the basis of her further work to enlarge and perfect her systems of life, that all provided food should have its fitting consumers. Nature is ever truthful and casts aside all her products that have been marred upon her wheel, and uses most those which come most perfect from her hand, and thus her progress is ever steady, or is improvement towards her best standard of each created species, under favoring circumstances; but is degradation where unfavorable, or man violates the law of his well-being. This is confidently said after such general survey as all who are intelligent may make, —all who will lift up their eyes and behold the operations of all living creation, or read the geological records,—not looking too constantly downward with limited vision as wedded to pre-conceived theory.

Darwin admits the dearth of facts to sustain his theory, and enters into explanations why they are not found. He says: "To sum up, I believe that species come to be tolerably well-defined objects, and do not at any one period present an inextricable chaos of varying and intermediate links; first, because new varieties are very slowly formed, for variation is

a slow process, and natural selection can do nothing until favorable individual differences or variations occur." Ib. 171. But if all the classes, orders and species come from one or two original and simple forms of life, there should be everywhere and constantly found intermediate transition links, at different stages of progress towards the new species, and presenting an inextricable chaos. This result is parried by the argument that the process is so slow that it is not seen. The more obvious conclusion would seem to be that this transitional process, or "inextricable chaos," are not seen because never happening. And Darwin candidly states (Ib. 173), "Here, as on other occasions, I lie under a heavy disadvantage, for, out of the many striking cases which I have collected, I can give only one or two instances of transitional habits and structures in closely allied species of the same genus, and diversified habits, either constant or occasional, in the same species. And it seems to me that nothing less than a long list of such cases is sufficient to lessen the difficulty in any particular case like the last." The difficulty was to conceive how an insectiverous quadruped could possibly have been converted into a flying bat. But it should seem this would occasion small difficulty to a theorist who could believe that bats and elephants and man himself, sprang from an ascidian, a radiate, or trilobite, or some other early simple form of life. He, in such case, becomes too carefully scrupulous for his own theory; and he further conscientiously says (p. 198), "we have seen in this chapter how cautious we should be in concluding that the most different habits of life could not graduate into each other; that a bat for instance, could not have been formed by natural selection from an animal which could only glide through the air." Let us observe his wise caution, and doing so we must reject his theory. He gives no proofs that justify his conclusions.

Again, Mr. Darwin is constrained to excuse geology for affording his theory but little support. Too few fossil specimens have been obtained; too many creatures have perished and left no likeness in the rocks. He says, "although geological research has undoubtedly revealed the former existence of many links, bringing numerous forms of life much closer together, it does not yield the infinitely many fine gradations between past and present species required on the theory; and this is the most obvious of the many objections which may be urged against it." Ib. 415. But he does not adequately answer this seemingly well founded objection. He excuses himself by the paucity of facts. Then it may be asked why has the theory been propounded before adequate facts have been gathered? Philosophy reserves the privilege of reprimanding her votaries who built their theories upon insufficient facts; and truth compels her to censure unsparingly. They are not permitted to indulge the ambition of theorizing before they have collected adequate materials for their edifice. Darwin has ranged widely and observantly the realms of nature, and we follow him interestedly; but he seems at fault in making his inductions from the facts he has learned; has built on an inadequate foundation; has made small things important, and overlooked the full

import of the great. If his theory were true, the facts for its support should exist by millions, and by billions. That his researches have not produced the facts he wanted, makes them tell more strongly against him. If all living life, and all that has been, came from first simple forms by slow changes, through all being up to the classes, orders, genera and species that we find in existence, and to have existed through all the geological eras, then intermediate links should have been endlessly abundant, and if but a hundredth part of the fossil kinds had been exhumed, they should necessarily have revealed the wanted evidence; living nature should also have abounded in ample testimony, by endless and inextricable confusion. To reach existing results, the process of change being gradual, the transition creatures should have teemed in myriad forms, other than is now seen in fossil or in life.

But why, if there was such immensity of transition as to account for the astounding changes wrought; why, if such endless variations were started in nature casually, or by chance, without reason or motive; how came nature to act so wisely as to bring order out of confusion and chaos, and on that order to take her stand more firmly than the mountains? In the transitional steps towards all the forms that have existed, of every shape and size from the little Rhizopod, Ascidian, Trilobite or Radiate, at the bottom of the ocean, up to the whale, mastodon and man, during an assumed necessary unimaginable length of time; how was all life so marshaled and placed as science now finds and arranges it, and finds it ever resistant of all change? Intelligence and will, even then, must have governed the proceeding and guided its purpose so that all should live and not work confusion. That Intelligence that could do so much in ruling nature, and could create the earliest life, surely could proceed more directly and without disorder, to create the kinds and species for whom that same Intelligence had provided the land, air, water and food, upon, in and by which they should all live, in congenial habitation. But Darwin never recognizes that Being as essential to his theory: No! the theory makes nature herself a substitute for God. Her forces it was, that from time to time jostled all creatures into slight variations, and then she herself selected the best chance-products of a capricious generation and continued them, and perfected without intending to perfect them, and the life of the weak and monstrous was extinguished, merely because not fittest to survive. If nature has such power over us and ours, and all living, shall we not impersonate and worship her as our deity? Men did do this, in various forms, but it was before science and revelation had dethroned the heathen deities. They are not likely to be restored to the worship of mankind, and thoughtful men generally believe in one supreme God.

And why has there been any limit to classes, orders, genera and species? And why has the growth of each and all creatures had their normal limit? Certainly by some intelligent Power that ruled over what are called the forces of nature. Why cannot the naturalist more frequently elevate his views to recognize an Intelligence, without whom all that he studies, himself included, can have little significance, or philosophy any worthy or

consistent foundation? God's order is the source of all science and philosophy. But Darwin neither acknowledges nor denies the ruling of the Deity; he invokes not His aid in the processes of nature; nor yet does he deify nature, but says this of her: "It is difficult to avoid personifying the word nature; but I mean by nature, only the aggregate action and product of many laws, and by laws the sequence of events as ascertained by us." It is obvious that the effect of the theory is displacement of God from His works and from the mind of the naturalist. But the laws of nature could not exist without nature had a Creator, and law a Law Maker. Darwin admits that the "highest intellects that have ever lived," have believed "there exists a Creator and Ruler," but his theory makes no account of Him. He would make nature Godless.

While Darwin's theory undertakes to rise from a few simple first forms of life to higher and more complicated, he denies any purpose of a designer to perfect his works, or any general tendency in nature to do so. He says, "whatever may be thought of this view, in none of the foregoing cases do the facts, as far as I can judge, afford any evidence of the existence of an innate tendency towards perfectibility or progressive development.' Ib. 132. The variations spring from individuals; but from what cause or with what purpose is not explained. The mass of the species remained unchanged, and so live on through many geological periods. He says, "Geology tells us that some of the lowest forms, as the infusoria and rizopods have remained for an enormous period in nearly their present state." Ib. p. 123. "I believe that many lowly organized forms now exist throughout the world, from various causes. In some cases, variations or individual differences of a favorable nature may never have arisen for natural selection to act on and accumulate. In no case, probably, has time sufficed for the utmost possible amount of development. In some few cases there has been what we must call retrogression of organization." p. 124. All, therefore, has come from chance individual variations. Thus all higher life, man included, has been lifted up, by chance-coming variations, generated in the lowest and lower forms of animal life, without purpose, design, or Designer: though the result is the exalted being man!

I make this statement with due care: He says, as to the mode of transition, "there is no reason to doubt that the swim-bladder has been converted into lungs, or an organ used exclusively for respiration. According to this view it may be inferred that all vertebrate animals with true lungs have descended by ordinary generation from an ancient and unknown prototype, which was furnished with a floating apparatus or swim-bladder." *Ib.* 183. This does not except the vertebrate man. He insists upon placing man in the order Quadrumana; says, "If man had not been his own classifier, he would never have thought of founding a separate order for his own reception." 1 Descent of Man, 183. He further says, "we will now look to man as he exists; and we shall, I think, be able partially to restore during successive periods, but not in due order of time, the structure of our early progenitors. This can be effected by means of the rudiments which man still retains, by the characters which occasionally

make their appearance in him, through reversion, and by the aid of the principles of morphology and embryology. The early progenitors of man were no doubt once covered with hair, both sexes having beards; their ears were pointed and capable of movement, and their bodies were provided with a tail, having the proper muscles. Their limbs and bodies were also acted on by many muscles which now only occasionally re-appear, but are normally present in the quadrumana." * * "The foot, judging from the condition of the great toe in the fœtus, was then prehensile; and our progenitors, no doubt, were Arboreal in their habits, frequenting some warm forest clad land. The males were provided with great canine teeth, which served them as formidable weapons." Ib. 198. "In a series of forms graduating insensibly from some ape-like creature to man as he now exists, it would be impossible to fix on any definite point when the term 'man' ought to be used." Ib. 226. That is, when he ceased to be monkey and became man, by physical transformation. Mr. Darwin has not attempted to show us in geology, in history or in life, a man at the point of transition, or to imagine or describe what he could be, or what the essentials to the change; nor any creature yet in the process of trasformation.

Thus, it is distinctly avowed that man was the result of this theory of evolution, and that his ancestor was an ape; whose ultimate progenitor was some trivial form of life in the bottom of the ocean. Thus by chance-begotten variations in the process of generation, all the million forms of life, in all their infinite distinctions, have been formed. Thus, through an instinct which no creature but man ever controls or disobeys, all living life has been built up; nay, all created creatures were created, except some first simple form, which alone it has been necessary for this theory to invoke, that there might be an inceptive speck of life for the beginning of a process of variable generations. But who gave this power to the first life and all later life to propagate such variable generations? Who created the sexes and the organs of generations? Who prepared the germs of life in one sex to be called into being by the other? Who gave the instinctive desire that starts gestation, and made the progeny to share the likeness and qualities of both parents? Who gave the parental instinct of protection of offspring, and who the requisite intelligence for their nurture? It is left fairly to be inferred that a Creator could only make the first simple form, and not the later higher life; or that life first came and worked on spontaneonsly. How could the creature of inferior instinct by generation create that which evinces the intelligence of the bee, the ant, the beaver and the elephant? The skill and polity of the bee, that made the ancients ascribe to her a spark of the Divine intelligence? Mere physical changes could not account for all these, and yet less for the mind of man. The Intelligence of instinct, and of mind, are not conceivably the product of matter, spontaneously or generatively, but we must ascribe such endowment to Him who could make the ant wiser than the human sluggard, who forfeits his manhood and dignity; to a Being infinitely superior in intelligence than

the highest intellect. If God did not create all creatures and endow them with the law of their being, why should He have cared for them as we perceive throughout all nature? He who ascribes nothing to God does not answer the question. The questions which our reason inevitably asks give him no trouble. He is tempted to deify nature but owns no Deity.

There are, indeed, common necessities to all life, that would go further to indicate its unity than the "rudiments" searched out. All must live upon the food that the earth, sea and air supply. All must have power of digestion and assimilation, and mostly have hearts, circulations, viscera, tissues, nerves and brains. The vertebrates have also flesh and bones. Now, in all this, there is a greater basis of brotherhood in all animated nature, than in the few small matters upon which the theory in question is built. That life in embryo shall start similarly, is as much to be expected as that the digestion, circulation, secretions and excretions should go on alike. But whatever be the incipient or embryolic resemblance, the mature development is always truthful to the demarcations recognized by the classifications of science. All that have nerves to feel are objects of kindness; but there fraternity ends.

Now, what are the particular things enumerated that declare our ancestors to have been apes? Here is the inventory of them in the author's words: "Some few persons have the power of contracting the superficial muscles on their scalps:" 1 Descent of Man, 19. "One little peculiarity in the external ear:" It is "a little blunt point projecting from the inwardly-folded margin or helix," p. 21. "The nictitating membrane, or third eyelid:" which in man "exists, as is admitted by all anatomists, as a mere rudiment, called the semilunar fold," p. 22–3. Of the sense of smell in man, Darwin says: "No doubt he inherits the power in an enfeebled, and so far rudimentary condition, from some early progenitor, to whom it was highly serviceable and by whom it was continually used," p. 23. "Man differs conspicuously from all the other Primates in being almost naked: but a few short straggling hairs are found over the greater part of the body in the male sex, and fine down on that of the female sex." * * "There can be little doubt that the hairs thus scattered over the body are the rudiments of the uniform hairy coat of the lower animals." p. 24. And he says, "we must consider the woolly covering of the fœtus to be the rudimentary representative of the first permanent coat of hair in those mammals which are born hairy." p. 25. "It appears as if the posterior molar or wisdom-teeth were tending to become rudimentary in the more civilized races of man." p. 25. "With respect to the alimentary canal, I have met with an account of only a single rudiment, namely the vermiform appendage of the cœcum." p. 26. The foramen near the lower end of the humerus is said to be found in one per cent. of modern human skeletons, but much oftener anciently, "one chief cause seems to be that ancient races stand somewhat nearer than modern races in the long line of descent to their remote animal-like progenitors," p. 27–28. "The *Os coccyx* in man, though functionless as a

tail, plainly represents this part in other vertebrate animals." p. 28. "It is well known that in the males of all mammals, including man, rudimentary mammæ exist." p. 30, which Mr. Darwin finds it "difficult to explain on the belief of the separate creation of each species." Darwin concludes this enumeration by saying, "The homological construction of the whole frame in the members of the same class is intelligible, if we admit their descent from a common progenitor, together with their subsequent adaptation to diversified conditions. On any other view, the similarity of pattern between the hand of a man or monkey, the foot of a horse, the flipper of a seal, the wing of a bat, etc., is utterly inexplicable." p. 31. And this conclusion may be admitted, if we believe creation had no Creator. But if all creatures had a Creator who endowed them with power to generate their like, but forbade them to generate their unlike, the explanation is clear, and makes that of Mr. Darwin wholly illogical. Was structure so great ever raised on so narrow a foundation! Indeed, this small basis for so tremendous a theory, necessarily brings into question the author's logical powers, and causes thoughtful men to set down much to personal idiosyncracy.

These rudimentary signs of man's relationship to the beast are of small things, indeed, but according to Darwin, of mighty significance: but to common apprehension of less account than the general functions common to mammal life, and the approximation of form between the ape and man; yet, all considered, leaving one a beast and the other an immortal being.

Is it not competent for the Creator to employ similar physical structures and functions in animals, and to give to all the benefits of adaptation to the food they are designed to feed upon, the situations they are to occupy, and the life they are intended to live, without making the one the offspring of the other? He who intended the good of all, would give the good in all to every species, so far as adapted to the welfare of each, and this we can more logically believe than that the man, the monkey, the horse, the seal, bat, &c., have blood relationship through a common ancestor. It is not a welcome belief that whether we eat "fish, flesh or fowl," we are perpetrating a kind of cannibalism, by feeding on distant relatives, though the degree of relationship cannot be traced, even with the help of Mr. Darwin.

And can science dispense with a Creator? The votaries of science may grope through special investigations until they cease to see God in His works. But just so far as they cease to see God as the author of Nature, they seem to cease to understand the logic of creation, in its pervasive features, wisdom and magnificence. Yet this theory of a generated creation, if it could be believed to be true or logical, must still be taken to rest upon a Creator and an upholder of all nature, and of the Universe, while it will not own Him as Author of all kinds of life. But life could not be, nor generation, nor birth, nor growth without His instant sustentation. And shall He not create His creation with all the distinctions of class, order, genera and species as we behold it? He must have created this earth, the sun that warms it, the air, water and food by which all life

must live; and He must have adapted all life to these conditions of nature in which it is placed. He who would deny the Creator in any part of His works must be prepared to do so as to the whole. Whatever be the purpose of the theory its tendency is to teach men not to believe in God or their own souls.

The reader will, if he yield his belief in any degree, reason thus, and say, if I sprang from an almost senseless piece of pristine life; if after my ancestors had arrived to the stage of evolution next preceding man, they were no more than monkeys; then, as I believe, these had no immortal souls so have I not an immortal soul: If I only differ from them by reason of a more perfect physical development, that of itself could give me no claim to an immortal soul. If I sprang from the beast I must die the death of the beast! And this idea would be strengthened by the supposed possibility of a reversal of the process of evolution, under the suspicion of which I would be brought; for Darwin admits that although the ancestral rudiments have become wholly suppressed for want of use, "they are nevertheless liable to occasional reappearance through reversion; and this is a circumstance well worthy of attention." Ib. 18. So, indeed, it appears if man be not yet sure of remaining man; if he may relapse to the ape, or become a new variety and be on the road to become a new species, let those look to the possible consequences who have an extra finger or toe, or whose canines or last molars, or slightly pointed ears, show kindred with the ape or donkey. If their descendants should cease to be man, can they in law inherit a man's estate? If there was such a transition upwards there may as likely be downwards. Who can tell what may be the freaks of nature, if nature be not in the keeping of God?

Mr. Darwin, writing in support of his theory does not show the facts that oppose that theory. He does not show the great differences that exist between the species that he would approximate. This is so both when speaking of the physical structure and the mental powers. When he passes to the admitted great mental and moral disparity between even the savage man and the most intelligent of the inferior animals, he advocates the cause of the latter, by stating what they do with their delegated power of instinct, and that they also exhibit instances of a glimmering reason. He, however, makes no near approximation, and admits the difference to be enormous though the comparison be made with the lowest savage. 1 Ib. 33, 67. The theory is really based but upon the physical structure, otherwise the ape would not have been selected as the progenitor of man, but rather the bee or ant, the beaver, dog or elephant, who are far more sagacious than the monkey.

What do we now behold over the face of the earth? Everywhere there yet abound the animals through which man is imagined to have descended, without having suffered variation or change, though exposed to the like causes supposed to have wrought their fellows into man; and everywhere men, savage or civilized, have been dispersed over the earth, and have so been without any evidence of material physical change, throughout all

the ages of their existence. Surely, to do away with this great fact, and the further fact that all is now proceeding as it did from the dawn of history, written or monumental, we must, in the absence of all other facts, except speculative inferences from very small things, called *rudiments*, conclude that God made man in the image he now bears, physical and mental, except as man has educated himself, as no other creature was ever endowed with the capacity of doing. The great lines of demarcation between the animal that has always followed only his assigned instinct, and the higher being that has always had power to invent and make the forces of nature, and all other animals subservient to his uses,—to invent language, writing, printing, and to indefinitely accumulate knowledge and perfect his own character,—have always existed over the earth, side by side, utterly incapable of fusion, and in extreme contrast, in their most marked characteristics. When we study by the microscope we are not to disregard the great things beheld by the unaided vision. If we see the mote, we must see the beam also.

So far I have but quoted from Darwin in relation to the theory of evolution. His simplicity and candor made it easy to answer him by his own books. A writer in the British Quarterly, for October, 1871, appears to have been assisted by microscopic observations, and says: "Almost every tissue of the newt, frog, toad, and green tree-frog, has individual characteristics of its own, which could be distinguished by one who was thoroughly familiar with the microscopic characters of the texture." "The nerve fibres in every part of the body of the newt, differ in many minute particulars from those of the frog." "In these animals not only do corresponding tissues exhibit peculiarities, but entire organs are totally different." And he points out the differences. "Again, if we take the skin of the four animals mentioned above, although it will be seen that there is a certain general agreement in structure to be recognized, there is not a texture of the skin that is alike in them all," and the differences are pointed out, with the assertion that "these seem to increase in number the more thoroughly and the more minutely the tissues are explored." P. 248–9. If this closer test shall continue to be applied, it probably may yet be believed that "All flesh is not the same flesh; but there if one kind of flesh of men, another flesh of beasts, another of fishes, and another of birds," and that men may safely eat all the others.

Professor Wyville Thomson, in a late lecture in the University of Edinburgh, said: "During the whole period of recorded human observation, not one single instance of the change of one species into another has been detected, and, singular to say, in successive geological formations, although new species are constantly appearing, and there is abundant evidence of progressive change, no single case has as yet been observed of one species passing through a series of inappreciable modifications into another." "Nature," November, 9th, 1871.

And here I would ask to read the forcible statement of our Secretary, Mr. Lesley, who adds his authority and force of logic to that of many eminent naturalists, and, I believe, nearly all the members of this Society

against the Darwinian theory: "If there has been a Darwinian development of animal life upon the planet, then it looks as if it had been carried out along four lines rather than one. Four stand-points of creative energy must have been assumed; four startings out of life must be accounted for; four mysteries, four miracles, four beginnings of creation, to be developed instead of one! But where all is mystery and miracle, additions are hardly noticeable. It becomes Mr. Darwin's business, then, not only to suggest some plausible, rational mode by which one species could gradually or suddenly pass the short interval which separates it from another; his explanation must suffice to bridge the awful chasms which have always kept these four great plans of structure separate, along the lines of their development. He must show us how an animal of radial growth could be developed into one of linear growth. Nay, he must fill up the immense interval between the plant and the animal; and, finally, the chasm between the atom of carbon or hydrogen, and the nucleated cell of albumen or fibrin. He must explain the genius of life itself, before he can make his law of natural selection stand for anything more than a beautifully worded description of the ills that all flesh falls heir to when it is born upon this planet. *How* it is born upon the planet is another matter, and remains unexplained by his hypothesis. We do not get rid of miracles by chasing them back along the ages to the starting point, and concentrating them there. A line of battle is not necessarily vanquished and annihilated when it is rolled up by an attack upon its flank, when there is a reserved force at the other end." "Man's Origin and Destiny," p. 78.

There is, however, one sufficing explanation of the mystery and miracle of life—it is this: that there is a God, and that man has an immortal soul; that this life is but the beginning of an endless being. The good fruits of this faith is an argument of its truth; and man has consciously the sense within him that the life eternal awaits him; and he already here communes with Deity. Such a life and such a soul must have had a Creator infinitely superior to the being created.

It is a decisive objection to the theory of Darwin that it takes account only of physical structure, while the greater disparity between man and all other animate creatures consists in his high moral, intellectual, and religious nature. Lyell cites, to sanction Quatrefages in saying, "that man must form a kingdom by himself, if once we permit his moral and intellectual endowments to have their due weight in classification." "Antiquity of Man," p. 495. "It is by something completely foreign to the mere animal, and belonging exclusively to man, that we must establish a separate kingdom for him," p. 494. Lyell also quotes to adopt the Archbishop of Canterbury, Dr. Sumner, in saying, that the comparison should not be taken from the upright form, nor even from the vague term reason," "but from that power of progressive and improvable reason which is man's peculiar endowment." "Animals are born what they are intended to remain. Nature has bestowed upon them a certain rank, and limited the extent of their capacity by an impassable decree. Man, she

has empowered and obliged to become the artificer of his own rank in the scale of beings by the improvable gift of improvable reason."—Ib. 496–7. And Lyell himself says, p. 498, "We cannot imagine this world to be a place of trial and discipline for any of the inferior animals, nor can any of them derive comfort and happiness from faith in a hereafter. To man alone is given this belief, so consonant to his reason, and so congenial to the religious sentiments implanted by nature in his soul; a doctrine which tends to raise him morally and intellectually in the scale of being, and the fruits of which are, therefore, most opposite in character to those which grow out of error and delusion."

The tendencies of the Authors now reviewed is the most unfriendly to that religious faith on which human welfare essentially depends; yet it is believed that good will result from the divulgence of their theories; but it will be because of their failure; because they will have compelled men to re-examine their faith upon the platform of Science, and thereby confirm their religion received by revelation. They will find in all truth an accord showing its source one; and in the constancy of nature the truthfulness of God. They will find that He who created ever rules His creation and compels it to obey His ordination. They will find that only man was made in likeness unto God, and that he was made to have dominion over all other living creatures. They will perceive that Science can erect no barrier between man and his immortal hopes; that the being of an immortal soul stands elevated above all other animated beings by a distinction that makes him but "a little lower than the angels," and a child of his "Father in Heaven"; a Father who condescends to commune with and be known of His children.

Stated Meeting, January 19, 1872.

Present 20 members.

Vice-President Mr. FRALEY in the chair.

A letter of acknowledgment for Transactions XIV. 1. and Proceedings, 84, 85, was received from the Bureau des Longitudes, dated Observatoire Nationale de Paris, Dec. 1871.

Donations for the Library were received from the Observatories and Royal Academy at Turin, Signor Denza, the Revue Politique, and M. A. P. Hovelaque, of Paris, the London Nature, Dr. Freeke, of Dublin, the Montreal Natural History Society, the editors of Old and New, and the American Chemist, the College of Pharmacy, Franklin Institute and Acad-

emy of Natural Sciences of Philadelphia, the editors of the Medical Journal, News and Library, and Penn Monthly, Mr. Eli K. Price, the Secretary of the U. S. Treasury, the Department of the Interior, the Engineer Department, and the Librarian of Congress.

Mr. B. S. Lyman offered for publication, in the Transactions, a map of the Punjaub Oil region, with explanatory text. On motion, this paper was referred to a committee, consisting of Dr. Genth, Mr. Lesley and Dr. Horn.

Mr. Cope communicated the following paper on a new Testudinate from the chalk of Kansas.

On a new Testudinate from the Chalk of Kansas.

By E. D. Cope.

(*Read before the American Philosophical Society*, Jan. 19, 1872.)

Associated with the remains of *Clidastes*, and other saurians, and at a distance of two or three hundred yards from the locality of the fossil *Protostega gigas*, were found some vertebræ of a Testudinate reptile, which approaches the type of *Trionyx* and *Chelydra*. It differs so strikingly from both, and from all others yet known, as to require notice, and as the parts preserved (caudal vertebræ) are those most likely to recur in a well-preserved state in strata of this age, I propose to establish a species and genus on them, to aid in the future identification of both strata and animal type.

The vertebræ have elongate centra concave below, and have well-developed diapophyses. A more anterior has transversely oval articular extremities; in another they are much less depressed. The former is the more anterior, being known as such by its larger diapophyses and much smaller articular surfaces for chevron bones; it appears probable, indeed, that this one has been without these appendages. It is, therefore, from the anterior part of the series, from no great distance behind the sacrum. Its position being thus determined, it may be described in detail as follows:

As observed, the centrum is elongate and depressed. The inferior surface at the cup is flat, but is arched upwards, descending again to the rim of the ball. The posterior two-thirds has a median groove, which terminates in a deep notch of the ball, which involves one-third of its vertical diameter, and widens backwards. The ball is transverse oval, and only moderately convex; near its upper margin a small deep pit interrupts its surface, having the appearance of an unusually large ligamentous insertion; its border slightly excavates the margin of the ball. The cup is a transverse oval, wider below. Its inferior and superior margins are so deeply (but openly) emarginate, as to reduce the concavity in the vertical direction very much. From the superior emargina-

tion, a deep groove descends to below the middle, probably for ligamentous insertion. The neural canal is subtrilateral. The neural arch is as usual in this group deeply emarginate in front, and much prolonged behind. The zygapophyses project beyond the ball, and the arch is contracted in front of them. Its upper surface has neither process nor keel, but is rugose for ligamentous and muscular insertion. The diapophyses have a wide base, and are subcylindric.

The surface is delicately reticulate rugose, coarsely rugose on the external faces of the zygapophyses. There are several small pneumatic foramina, the largest being in the bottom of the groove of the lower face.

Another vertebra differs in being rather more slender, and in having an obtuse keel of the neural arch. The pit of the ball is wanting, and the inferior emargination. The chevron articulations are larger, and the groove of the cup occupies the middle, instead of the upper half of the cup.

Measurements.	M.
Length of centrum (greatest)	0.27
Length of centrum { vertical	.01
Length of centrum { horizontal	.017
Elevation top neural arch above floor neural canal	.013
Length of arch on median line above	.02
Width " in front of posterior zygapophyses	.012

A metacarpal or metatarsal-bone, was found near though not with the vertebræ, and probably belongs to the same animal. If metatarsal, it is much stouter than in *Trionyx*, but is more likely to be metacarpal. It is about as long as the vertebræ, centrum and arch together. The proximal end is transversely truncate, compressed L-shaped; the shaft compressed sub-quadrate, the articular extremely hour-glass shaped, with an inferior projection for the insertion of a flexor ligament. Length, M. .034; proximal diameter, .013.

These vertebræ indicate a genus with elongate tail like that of *Chelydra* or probably longer; but they differ from those in that genus, by their procoelian character. An approach to the incised margins is to be found in *Trionyx;* but in those of that genus, where this character appears, the diapophyses are largely developed. The genus is evidently quite distinct from anything known, and we await further remains with interest. The species is much smaller than the *Protostega gigas*, and about equal to the Mississippi *Macrochelys*.

It may be called CYNOCERCUS INCISUS. The remains on which it is established were found by Sergeant Wm. Gardner, of my geological expedition in Kansas, in the yellow chalk near to Butte's Creek, south of Fort Wallace.

The discovery of this species and of the *Protostega* constitutes the first indication of the existence of *Testudinata* in the cretaceous formation of Kansas. The author originally pointed out the existence in it of

Sauroptergia and *Pythonomorpha*, and during the expedition just mentioned, obtained portions of *pterodactyles* and of a crocodilian of the genus *Hyposaurus*. The latter order has not been previously known from that region, and their remains are not common. Prof. Marsh's exploration in the Cretaceous of Kansas added *Pterosauria*, but he has not reported any *Crocodilia*, as I once thought, and incorrectly stated. (Proc. Am. Phil. Soc. 1871, p. 174.) The crocodile may be called *Hyposaurus vebbianus* in recollection of Dr. Wm. E. Webb, of Topeka; it is similar in size to the *H. rogersii* of New Jersey.

An anterior cervical vertebra presents the following characteristics: It is that one in which the parapophysis occupies a position opposite the lower third of the vertical diameter. In it the centrum is stout in form, the articular faces but little concave, the posterior a little more so than the anterior. The anterior is almost regularly hexagonal, the posterior sub-round, a little deeper than wide. The inferior surface possesses a strong obtuse median carina, which disappears in front of the posterior margin. Anteriorly it terminates in a short obtuse hypapophysis. The suture of the neural arch is very coarse. Surface of the bone smooth.

	M.
Length of centrum	.037
Diameter, " anteriorly, vertical	.037
" " " horizontal	.031
" " posteriorly, vertically	.032
" " " horizontally	.031
Length of surface of parapophysis	.015

As compared with the *H. rogersii* of the New Jersey Cretaceous, this vertebra is shorter and stouter, and the extremities less concave; the suture for the neural spine is much coarser.

This crocodile was discovered in a bluish stratum, belonging to the Benton group, or No. 20 of Meek and Hayden, encountered in digging a well in Brookville, Kansas.* This point is considerably east of the exposure of cretaceous rocks seen near forts Hayes and Wallace. It is interesting as the first of the *Crocodilia* found between the Tertiaries of the Rocky Mountains and the Cretaceous of New Jersey.

It was given me by my friend Dr. Wm. E. B. Webb, of Topeka, to whom science is also indebted for the *polycotylus latipinnis*, I have dedicated the species to him.

Dr. Henry Hartshorne read the following paper on Organic Physics.

*This stratum is similar to that in which Dr. Hayden found the fish *Apsopelix saurïformis*, at Bunker Hill.

ON ORGANIC PHYSICS.

By Henry Hartshorne, M. D.

(*Read before the American Philosophical Society, Jan.* 19, 1872.)

In the title chosen for this paper, there may appear to be something anomalous or contradictory: organic science and physical science being commonly regarded as almost incommunicable departments. But as we have long had, already, organic *chemistry* and animal *mechanics*, the tendencies of opinion, and to some extent the clearly rational interpretation of facts, now favor the re-inclusion of organic natural science under the wide term physics, from which it became long ago separated upon grounds of theory, and as it may still continue to be, for the classifications of convenience.

The proneness for unification, so natural to human intelligence, being methodically sanctioned under what is called the "law of parsimony," the question from period to period in all fields of thought is, how far can we *legitimately get* in our simplifications and unifications? Provisionally, at least, we must mark our steps; as, what is done in these unifications of science is to aim at the "reduction of our complex symbols of thought to the simplest possible" *appropriate* "symbols." When the alchemists thought that they might transmute or reduce all elements to one, they did not succeed. There are now some theorists who would reduce all our ideas of law, order, and causation in nature to the one idea of *continuity*. I believe that they will not succeed, in the end, better than the alchemists. This endeavor is, just now, being made especially in the region of life; and while, as already said, there is enough to sustain fully the proper *inclusion* of vital phenomena along with the other phenomena of nature as *physical*, I hold that there is not enough to establish this *identity* or immediate continuity, in the sense in which it has been asserted by some biologists. Let us address ourselves for a few moments to the elements of this question in its recent aspects.

First: What do we mean by life? What is it that we are to regard as differentiated from, or identified with, the other physical forces of nature? We may drop out at once the old idea, that all actions of a living body, such as digestion, circulation, aeration, and the rest of the *special* functions, are properly called vital; or that these need to have any peculiar or *specific* force, or phase of force, to explain them. Digestion is chemical; circulation, mechanical, and so on. By proper exclusion, then, we come down to this: that only one (perhaps a two-fold) process is truly vital, in the sense that its facts come under the category of no other force of nature, under no other name hitherto known to science, but that of life. And this process is *assimilation*, with type-formation or definite organization as its result: the segregation of matter in a peculiar molecular state, whence comes its assumption of peculiar though rapidly changing forms; the chemical instability of the matter being in direct

correspondence with the mutability of its forms. Life is then a change, a molecular motion; and it needs a name for itself as distinctly as heat motion, electrical, or any other kind of movement. But, is it the direct resultant of those other movements? Is organic evolution simply in the line or plane of the composition of the cosmic forces, gravitation, heat, light, electricity, magnetism, chemism, so as to be the mere outcome of these? I would say, no. And this is a very different thing from denying the *correlation* of the vital and physical forces. They are clearly correlative; but correlation is not indentity. And the question is a deep one, what their exact relation is; it is now one of the cardinal questions in science. Because of the wide variety of its bearings, let us regard their most general aspect first.

Grant, as a postulate, the "conservation of force." Then there follows: 1st, as its corollary, that not only is the total of force in the universe never diminished, but, conversely, this totality is never, by physical causation, *increased*. As apparent exhaustion of force is only its transmutation, so apparent increase of it must also be only transmutation of it.

2d. No *change*, in the nature or direction of any force, can, in accordance with the second law of motion, be either uncaused or self-caused, that is caused by the force itself. Every such change must have a special, sufficient cause. When, then, the laws and tendencies of gravitative, electric, magnetic, chemical and heat and light forces are known, and are found to promote, by preference in all instances, the formation of compounds of *stable* equilibrium, by the union of carbon, hydrogen, oxygen, sulphur, and phosphorus, etc., we must expect this to be *uniformly* the result of their direct action. And, therefore, when we find conspicuously unstable compounds to be formed of those same elements, although in the presence of the same general forces, we ought to conclude the formation of such compounds to be the result of *another* definitely acting force. When the force x has been proved always to act in the line A B, and the force y to act in the line C D, we must be sure that a force acting in the reverse line B A, or D C, or in any line intermediate between B A and D C, cannot be either the force x or the force y, or a force resulting from the composition of X and Y, but must be another force, say z. Assuming the existence of z, we may then endeavor to ascertain its relations to the other forces; and we may also inquire whether there may or may not be still other forces of whose composition it is the resultant. So we ought to conclude that there is a special force, or mode, or line of force, whose action is the assimilation and new construction of organizable, protoplasmic, or bioplasmic matter, because the action so named involves a movement of elements in direct opposition to that produced by the other known forces, as shown especially and invariably by the action of those forces upon the same matter, when death occurs.

I may introduce here a remark upon the chemical part of the discussion; whether, as a matter of *induction*, all *a priori* reasoning apart, we are warranted in saying that organizable matter is and can be never produced

by chemical or any other general cosmic forces. Since Wöhler's first formation of urea from carbonate of ammonia, many years ago, this has been much argued upon. Numbers of organic substances have since been made by Berthelot and others, by more or less nearly direct synthesis. But mark this. With the single exception, *possibly*, though not probably, of neurin (that exception remaining very doubtful yet, especially as the substance so designated as made by synthesis, is reported to be crystalline or crystallizable), all the compounds so formed are not organizable, but what I would call *post-organic* substances, products or educts of retrograde or downward metamorphosis; excreted or secreted,—made in animal or vegetable bodies not by their life-force as such in tissue formation, but by its "composition" or balance *with other forces*, in the retrogressive metamorphosis, the approach toward waste and death. It is not *germinal* but effete *formed* matter, to use the words of Beale. Such, for instance, is even quinia, though not yet made by synthesis. Such may be neurin itself, in the form in which we get it after the death of an animal, since no tissue is more prone to change soon after death than the nervous. In fact, if with Lehmann, Moleschott and Huxley, chemists should assert that life is only a *property* of certain substances, and, as some chemists at least say, that those substances can be made in the laboratory, then we must hold them to the test; and deny the formation of any of those substances themselves, *until they are shown to manifest all their properties, including life.*

Time cannot be allowed in this paper, more than to allude to the present aspect of the closely connected question as to the evidence of experiment, in reference to the origination of minute forms of life. After the controversy (which was very active in the day of Crosse's electrical experiments) had, by elimination, been narrowed down to a chronic debate between Pasteur and Pouchet, we are now surprised by its assuming larger proportions, with Owen, Clark, Hughes Bennett and Bastian, coming out as decided heterogenists, or advocates of abiogenesis. Similar observations and like arguments, however, come up again and again. No better case has ever been made out for heterogeny than by Charlton Bastian in his papers in "Nature," 1870. I need not dwell on the known difficulty of exactness in such experiments, from the first preparation of the apparatus down to the last examination of the results under the microscope: a difficulty, as regards the total exclusion of foreign particles, pronounced by some experts to be insurmountable.

We need only observe here that Bastian's protest against Pasteur's assumption, that the prior weight of improbability is *against* the heterogenic theory, is not warranted; as the burden of proof certainly does rest with the heterogenists. It being perfectly well known that no experience exists of the beginning of life of *larger* forms, however simple, without parentage, we may say that since nothing larger than $\frac{1}{10000}$ of an inch has ever been known to begin life in an entirely inorganic medium, the probability is vast that nothing *smaller* than $\frac{1}{10000}$ of an inch diameter ever does so. While we are not able to say that it is *impossible*, those who assert

it must bring most cogent evidence. And the legitimate *alternative*, in regard to all the *heating* or boiling experiments, is, whether we are to apprehend in them new evidence of the resistance of some low living forms to the usually destructive influence of heat, or to assume the total effect of this, and then conclude that a *de novo* origination of life has really occurred. There are many facts which sustain the choice of the former interpretation; facts, for instance, concerning confervoid vegetation in boiling springs, and such as those observed by G. Pouchet and others, proving the marvellous tenacity of rotiferous animalcular life. Jeffries Wyman's experiments, moreover, seemed to show, that though four hours would not, five hours boiling would, prohibit the appearance of any vitality in the materials under his examination. Frankland and Calvert have since strongly confirmed the same conclusion by their careful experiments. No one, however wedded to heterogeny, can say that we are yet at the end of our knowledge of the limits of vital resistance to physical agencies, including heat. But note further: that putting aside (although Professor Huxley does not) as unjustifiable, the supposition that it was possible for an observer like Bastian to be mistaken as to the really organic character of the very minute filaments and sporules, observed by him in tartrate of ammonia or other solutions, under restricted conditions, we must find in them at least something extraordinarily different from the life which we are accustomed to observe; since a very important part of the whole process was the entire exclusion of air; so that if there was life, it was such only as could exist in distilled water, or *in vacuo*. And here, just as in the controversy upon the essential distinctions between animals and plants, since deoxidation and oxidation, fixation of carbon and its elimination, are directly opposite processes, though we may not yet find their separating line, still the line must *exist somewhere*. And it would be taking for granted a great deal more than any evolutionist has a right to do as yet, to suppose, not only that Bastian had thus manufactured sporules and filaments living in airless tartrate of ammonia, but that all he would need would be some greater variety of conditions and time to evolve from them the whole system of organized nature. Bastian himself has not yet asserted this.

A word more about the above named *opposition* between vital and other cosmic forces. It may be stated thus: According to the nebular theory mostly accepted now as the basis of cosmogony and evolution,—the formation of the worlds of our solar system has been and is attended constantly by the integration of matter and the dissipation of force. I have, in this expression, used Hebert Spencer's words. The spheres in consolidating from diffused nebulous matter *give out* force as heat. But, per contra, *organized beings* integrate matter, and *at the same time accumulate force*. In the language of Professor Barker's able discourse on the Correlation of Vital and Physical Forces, "the food of the plant is matter whose energy is all expended; it is fallen weight. The plant-organism, in a way yet mysterious to us, converts the actual energy of the

sunlight into potential energy within it. The fallen weight is thus raised and energy is thus stored up."

As Dr. Barker adds, the force which is stored up is undeniably physical; but I remark further, that the process *by which* it is *stored* is of another order, and involves a different kind of physical force movement from that by which it is *evolved* and expended.

What more can be made out about this mysterious force of life? Not much as yet; but enough, perhaps, to give encouragement to investigation. Reduced to its simplest element, namely, the cell, or the physiological unit, life is a process of *incretion* and *excretion*. What goes in as food is made into tissue, and (after functioning) comes out as waste. The functioning is secondary to it as *life*, though no doubt in itself primary under the view of purpose. The organic cell converts crystalloid atoms or molecules into colloid molecules. Now what is the difference? not merely in the fact of different degrees of diffusibility, but in the state of the particles; the reason why they are colloidal? May we not conjecture, that it may be owing to a differentiated movement of the *atoms?* Clausius and others have long since given reason for supposing that the particles of all gases are in incessant motion among themselves. May not these atomic movements of the three gases, nitrogen, hydrogen and oxygen, all of which are associated with carbon in bioplasm, be in some manner retained in the integration of the organic cell?

Life-motion is probably not *undulatory*, like light, heat and electrical movement, but rotary or cycloidal. For an analogy, I would allude, somewhat too boldly, to the theory of some astronomers, of the present constitution of Saturn's rings; of multitudinous small masses incessantly in motion among themselves. And the occasion for brevity in this communication must be the excuse for crowding, before I conclude, yet other questionable proposals of analogy; as of the minute microscopic cell, with its inward, and outward currents through undiscoverable pores, with even the incretions and excretions of the sun and its photosphere; whose outward and inward cloud-currents are now being so laboriously studied. Somewhat less remote, certainly, is the suggestion of analogy (*not* identity) of life-actions with effects of some of the other forces of physical nature. I would regard sexual union which (except in mere *dividuation*, such as the life of a tree in its cuttings, or the fissiparous generation of animals) is, until heterogeny or spontaneous generation be proved, the only method of the indefinite continuation of life,—I would regard this sexual union as the true analogue of chemical union. The importance of bi-sexual polarity in organic nature has hardly yet been fully appreciated. Carbon and oxygen uniting give out *heat*, and carbonic acid which escapes. Organisms of two sexes, say the pollen cells and germ cells of a plant combine, and evolve *life*-force, whose products do *not* escape, but *remain* as organizable and organized protoplasmic matter; developing new cells in connection with each other. Yet another analogy with physical force-action may be presented. It is known that phyllotaxis, or

the leaf and branch arrangement of plants, follows a spiral law, arithmetically calculable, and showing a striking correspondence with the order remarked in the successive distances of the planets of our solar system from the sun. But what this phyllotaxis still more readily recalls to us is,—the helix of the electro-magnet; or, rather, of the magneto-electric apparatus. As the opposite polarities of the magnet are to the current of the helix of wire, so may be—of course, we do not say is—sexual bi-polarity to the spiral phyllotaxis. While a spiral tendency or movement cannot be so clearly traced in animals, yet some indices of what we may call *organo-taxis* are not wanting. As opposite leaves are held to represent a double spiral, and whorls two or more, so the bilateral symmetry of vertebrates, articulates and some mollusks, and the whorled form of radiates and cœlenterates, may present or imitate results of a similar polar force.

Another analogy, with which physicists may have more patience, is of a *reverse* kind, with heat. As a spark of fire sets burning an indefinite amount of combustible matter within its influence, so a spark of life vitalizes successively an indefinite amount of viable, organizable material as food. But the difference is, as remarked already, that while the increment of heat-force instigates the continuous *reduction* of less stable conditions of matter to those more stable, the increment of life-force *elevates* materials from stable into unstable substances, with constantly transmuted forms.

To conclude: By no such crude analogies as these can any one imagine that the mystery of life is to be altogether removed. These remarks are presented mainly to suggest and show that inquiry into life-force and its attributes may now legitimately follow methods like in nature those used in studying the other physical forces; and to expand to some extent the germinal thought, that, while life or life-force must yet be always differentiated from the other cosmic forces, it is, like them, a motion, or mode of motion, whose study is a part of physics—organic physics.

I would add that such a view of the correlation of biology with the other physical sciences no more interferes with a theistic and teleological view of creation than does the (now familiar) resolution of many once called vital actions (as digestion, circulation, blood-aëration) into chemical or physical acts, the results of ordinary forces of nature, which are *collocated* in the animal body under the conditions of vitality. To analyze is not to create, or even to show how creation was effected; much less is it to afford a negation of the fact of creation itself. Yet, to analyze is always legitimate in science, so long as it is done accurately, step by step; and this, whether it point to biogenesis or abiogenesis, to the origin of types by interrupted appearances or by evolution.

The discussion of Mr. Price's paper, read at the last meeting, being in order, Mr. Cope made the following remarks:

As the essay read before this Society under the above title, adduces no facts for or against the theory of Evolution not already known, the writer does not propose to criticise it as a whole. His object is to correct some statements of supposed fact, which are germane to the argument of the essay, in which its author has been led astray by the statements of others, or want of familiarity with the subject.

The erroneous statements are the following :

1st. That the gradations of variational and specific form seen among domesticated animals are peculiar to them, not being found among animals in the wild state ; and are therefore due exclusively to the influence of human interference.

2d. That fertile hybrids do not exist in the wild state, and that their existence between domesticated varieties is therefore evidence of their common origin.

3d. That transitions from species to species, as to form and other essentials, occur neither in the present period nor in the succession of geologic strata.

4th. That the examples of intermediate forms, or supposed transitional structures, on which the evolutionists rely, are abnormal or monstrous, or otherwise insufficient for the use made of them.

These are four very natural popular fallacies, and the present seems to be a suitable opportunity for exposing them.

First. That graded varieties and unstable specific forms do not exist outside of domestication, and are due to its influence, etc. To find an unqualified contradiction to this statement, it is only necessary to refer to the diagnostic tables and keys of the best and most honest zoölogists and botanists. It is true that these diagnoses are dry reading to the non-professional, yet they embrace nearly all that is of value in this part of biological science, and must be mastered in some department, before the student is in possession of the means of forming an opinion. The neglect to do this explains why it is that, after all that has been written and said about *protean* species, etc., the subject should be so little understood. The fact is thus : That in every family or larger group of animals and plants, there exists one or more genera in which the species present an aggregation of specific intensity of form ; that is, that species become more and more closely related, and, finally, varieties of single species have to be admitted for the sake of obtaining a systematic diagnosis, which will apply to all the individuals. These varieties are frequently as well marked as the nearly related species, so far as *amount* of difference is concerned, the distinction between the two cases being that in the varieties there is a gradation from one to the other ; in the species, none. Nevertheless, between some of the varieties, transitions may be of rare occurrence, and in the case of the "species," an intermediate individual or two may occasionally be found. Thus it is that differences of the varietal and of the specific kinds are distinguished by degree only, and not in kind, and are therefore the results of the operation of uniform laws. Yet, according

to the old theory, the varieties have a common origin, and the species an independent one. To cite examples of what is asserted, the monograph of the Tenebrionidæ, by Dr. Horn, in the Transactions of this Society, especially the genus *Eleodes*, may be mentioned, or the essay on the genus *Ptychostomus*, in the writer's "Fishes of North Carolina," in the Proceedings of the Society, may be consulted.

It is true that in but few of these cases have the varieties been seen to be bred from common parents, a circumstance entirely owing to the difficulties of observation. The reasoning derived from the relations of differences appears to be conclusive as to their common origin, unless we are prepared to adopt the opposite view that the varieties have originated separately. As these avowedly grade into individual variations, we must at once be led to believe that individuals have been created independently: a manifest absurdity.

But variations in the same brood have been found among wild animals; for example, both the red and gray varieties of the little horned owl (*Scops asio*) have been taken from the same nest.

As further examples of gradation between species and varieties, found in nature, I only have to select those genera most numerous in species and *best studied*. Among Birds: *Corvus*, *Empidonax*, *Buteo*, *Falco*, etc.; Reptiles: *Eutænia*, *Anolis*, *Lycodon*, *Naja*, *Caudisona*, *Elaps*, *Oxyrhopus*, etc.; Batrachia: *Rana*, *Hyla*, *Chorophilus*, *Borborocoetes*, *Amblystoma*, *Spelerpes*, etc.; Fishes: *Ptychostomus*, *Photogenis*, *Plecostomus*, *Amiurus*, *Perca*, and many others.

These *protean* genera are not the majority of those known to naturalists, but are quite numerous. That the variability depends on a peculiar condition of the animals themselves, and not on domestication, excepting in so far as it produces these conditions, is plain not only from the above facts, but from those observed in domestication. It is well known that while pigeons, fowls, cattle, dogs, etc., are very variable or "protean," the pea-fowl (*Pavo*) has maintained its specific characters with great accuracy, during a period of domestication as long as that of the other species named. The same may be said of the Guinea (*Numidia*) and the Turkey (*Meleagris*). These facts show that domestication is only a remote cause of variability.

Second. That hybrids do not occur among wild animals, etc. The affirmative of this question is no more important to the view of evolution than the reverse; nevertheless, if hybridization be regarded by any as evidence of common origin, as the author of "Phases of Modern Philosophy," etc., believes, then some wild species are undoubtedly descended from the same parents. There are a few fertile hybrids in nature, though some animals have been stated to be such without sufficient evidence; for example, the *Colaptes ayresii* (woodpecker) is thought by Professor Baird to be a permanent hybrid between the Eastern *C. ornatus* and Californian *C. mexicanus*, and as it occupied the region between the two (Upper Missouri) there is every reason to believe that such is the case, especially as

it mingles and breeds freely with both the others on the borders of their range.

Third. That transitions from species to species in the present periods have not been observed; nor have they been discovered in passing upwards through strata of the earth's crust.

The all-sufficient answer to this statement is to be found in the imperfection of our system of classification already pointed out. Thus, if we first assume with the anti-developmentalist, that varieties have a common parentage, and species distinct ones, when intermediate forms connecting so-called species are discovered, we must confess ourselves in error, and admit that the forms supposed to have had different origin, really had a common one. Such intermediate forms really establish the connection between species, but the question is begged at once by asserting unity of species, and therefore of origin, so soon as the intermediate form is found; for, as before observed, it is not degree but constancy of distinction, which establishes the species of the zoölogical systems. Transitions between species are constantly discovered in existing animals: when numerous in individuals, the more diverse forms are regarded as "aberrant;" when few, the extremes become "varieties," and it is only necessary to destroy the annectant forms altogether, to leave two or more species. As the whole of a variable species generally has a wide geographical range, the varieties coinciding with sub-areas, the submergence or other change in the intervening surface would destroy connecting forms, and naturally produce isolated species.

Formerly, naturalists sometimes did this in their studies. A zoölogist known to fame, once pointed out to me some troublesome specimens which set his attempts at definition of certain species at defiance. "These," said he, "are the kind that I throw out of the window." Naturalists having abandoned "throwing" puzzling forms "out of the window," the result of more honest study is a belief in evolution by four-fifths of them.

Fourth. That the "variations" or intermediate types pointed to by evolutionists in favor of their positions, are exceptional, abnormal, or too few to be available in demonstration of the origin species in general, etc.

The cases of transition, intermediate forms, or diversity in the brood, observed and cited by naturalists in proof of evolution, are few compared with the numbers of well defined, isolated species, genera, etc., though far more numerous than the author of the article criticised is aware of. Their value in evidence of the nature and origin of the permanent forms, is, it seems to me, conclusive, and to a certain extent, complete. By the inductive process of reasoning we arrive at a knowledge of the unknown from the known, a process which we act upon in our daily affairs, and one which constitutes the key to knowledge. It rests upon the invariability of nature's operations under identical circumstances, and for its application merely demands that analysis and comparison shall fix that the nature of that of which something is unknown, is identical with

that of which something is known. We then with certainty refer that something which is known, as an attribute of that object of which the same quality had been previously unknown.

In application to the question of evolution the following preliminary facts may be assumed:

1. Many species are composed of identical elemental parts which present minor differences.

2. Some of these differences have been seen to arise "spontaneously;" that is, characters have made their appearance in offspring of parents which did not possess them,—or what is the same thing, are known to exist in individuals whose parentage is identical with others which do not possess them.

3. The gradation of differences of the same elemental parts is one of degree only, and not of kind.

4. Induction: Therefore all such differences have originated by a modification in generation, or have made their appearance without transmission, in descent.

This induction is one of the forms in which the proof for evolution appears, though a more cogent argument is that already presented in Chapter I, of the paper entitled "On the Method of Creation," etc., Proceedings A. P. S., 1871.

The fact that in the majority of species, their origin by descent with modification has not been directly observed, in no wise invalidates the above argument. Unless they present positive evidence against such origin, these are absolutely silent witnesses. He who cites them against evolution commits the error of the native of the Green Isle, who was present at a murder trial: "Although the prosecuting attorney brought three witnesses to swear positively that they saw the murder committed, I could produce *thirty* who swore that they did not see it done!"

Finally, it may be asserted that the Theory of Development is the only theory of creation before the scientific world at the present time. The author of "Some Phases," etc., says, in opposition to it, that *God made* the species, and that their gradual evolution dispenses with His interferences and authorship. Will our author explain to us *how* God made the species independent from the start? No opponent of development has attempted to do this, and until it is done, there can be no theory or doctrine in the field other than that of Evolution. The Evolutionists not only believe with the author criticised, that God made all things, but they attempt to show in the field of biology, *how* He did it.

If they are correct in their interpretation of the facts, there can be, and is, no interference between their views and the purest morality, and the most faithful religion.

Other members took part in the discussion.

On motion, Mr. Lesley was elected Librarian for the ensuing year.

On motion, the nomination of Standing Committees being in order, those of the preceding year were continued.

On motion, the reading of the Catalogue of Members was dispensed with.

Pending nominations Nos. 679, 689, and new nominations 690, 691 were read.

Nominations Nos. 678 to 688 were spoken to by Nominors and balloted for; and on a scrutiny of the ballot boxes, by the presiding officer, the following gentlemen were declared duly elected members of the Society:

Prof. W. C. Kerr, State Geologist of N. Car., Raleigh, N. C.

Mr. La Motte Dupont de Nemours, Wilmington, Del.

Prof. William P. Trowbridge, of Yale College, New Haven, Conn.

Dr. William Elder, of Philadelphia.

Francis Bowyer Miller, Esq., of the Royal Branch Mint at Melbourne, Aus.

Mr. Guillaume Lambert, Professor of Chemistry in the University of Louvain, Belgium.

Mr. Persifor Frazer, Jr., Assistant Prof. Chemistry, University of Pennsylvania, Philadelphia.

Mr. George W. Hough, Director of the Dudley Observatory, Albany.

Mr. William A. Stokes, of Philadelphia.

Mr. Edwin J. Houston, Professor in the High School and Franklin Institute, Philadelphia.

And the Society was adjourned.

Stated Meeting, February 2d, 1872.

Present, fifteen members.

Vice-President, Mr. FRALEY, in the Chair.

New members:—Mr. Stokes, Dr. Elder and Prof. Persifor Frazer, Jr., were introduced to the presiding officer and took their seats.

Letters accepting membership were received from Prof.

Wm. C. Kerr, dated Raleigh, N. C., January 29th; Prof. Edwin J. Houston, dated 3603 Chestnut street, Philadelphia, January 30th; Prof. Persifor Frazer, Jr., dated 137 S. Fifth street, Philadelphia, January 28th; and Mr. Wm. A. Stokes, dated 2026 Delancey Place, Philadelphia, Jan. 25th, 1872.

A letter of envoi was received from the Fondation Teyler.

Letters enclosing the draft of a memorial to Congress, for an appropriation for observing the transit of Venus, were received from Rear-Admiral Sands, dated U. S. Naval Observatory, Washington, D. C., Jan. 18th, 1872, and Jan. 30th, 1872.

On motion of Dr. Ruschenberger, a committee, consisting of Dr. Ruschenberger, Prof. J. F. Frazer and Mr. Marsh, was appointed to consider the subject of preparing a memorial to Congress for an appropriation for observing the transit of Venus, in accordance with the recommendation of Rear-Admiral Sands.

A portrait of D'Alembert, by Rembrandt Peale, was presented to the Society by Mr. Joseph Harrison, of Philadelphia, who purchased it at the sale of the Peale Collection some years ago. On motion, the Secretaries were instructed to tender the thanks of the Society to the donor.

The Secretaries laid on the table for the examination of the members the 87th number of the Proceedings of the Society, just published.

Donations for the Library were received from the Belgian Academy, the Revue Politique; Nature; the Canadian Naturalist; Salem Institute; Old and New; Silliman's Journal; Journal of Pharmacy; Franklin Institute; Academy of Natural Sciences, Philadelphia; the Chief of U. S. Engineers; the Smithsonian Institute; the New York Anthropological Society, and Senator Sumner.

The Anthropological Institute of New York; the Voigtländsche Verein für Naturkunde, Reichenbach a-V.; the Zoolog-Mineral. Verein, Regensburg; and the Verein für Vaterländ: Naturkunde, Stuttgart, were, on motion, placed on the list of corresponding Societies, to receive the Proceedings.

The death of Mr. Edward Miller, a member of the Society,

on the 1st instant, at West Philadelphia, in the 62d year of his age, was announced by Mr. Fraley, with appropriate remarks. On motion, Mr. Solomon W. Roberts was appointed to prepare an obituary notice of the deceased.

The Committee to which was referred the paper and map of Mr. Lyman, on the Punjaub Oil Region, reported in favor of its publication in the Transactions.

Mr. Lyman exhibited a large map of the region between Rawul Pindee and the Salt Range, published by the British Government, and described the zoological structure and mineralogy of the country.

Dr. G. B. Wood, referring to his previous communications of the use of potash salts in agriculture, made some additional remarks on that subject.

Professor Cope offered for publication in the Proceedings a paper on "The Families of Fishes of the Cretaceous Formation of Kansas."

Pending nominations Nos. 689, 690 and 691 were read, and the meeting was adjourned.

Influence of Fresh Wood-Ashes on the Growth of Wheat, Potatoes, &c.

By Dr. George B. Wood.

(*Read before the American Philosophical Society, February 2d*, 1872.)

In a communication made to the Society at their meeting of January 6th, 1871, in relation to the efficiency of fresh wood-ashes in the revival of prematurely failing fruit-trees, I took occasion to suggest that, upon the same principles, they might prove equally efficacious in preventing the failure or deficiency of the wheat crop, so common of late in the old settled parts of our country. The opinion was based on the large proportion of potassa found in the ashes of the wheat plant, when burned in the growing state; exceeding as it does twenty times that of common unleached ashes. Wheat, therefore, requires a very large relative proportion of the alkali for its growth, more than can be derived from an exhausted soil, even when aided by manure, which, though it contains a considerable quantity of the salts of potassa, cannot yield enough to the growing wheat to insure a large crop. But this was mere speculation, and the question could be decided only by experiment. Accordingly, as stated in my last communication, I selected an acre of ground, and dividing it into three parts, treated one with ashes alone, another with ashes

and swamp-muck conjointly, and the third with muck alone; the muck being applied as ordinary manure, and the ashes sprinkled upon the ploughed ground at the same time with the sowing of the wheat, and then harrowed in along with it. This was done early in the autumn of 1870. Even during the same season, the eye could readily perceive the more luxuriant growth of the wheat where supplied with ashes, and a line of division between this portion of the lot, and that simply manured, was very obvious. But the point in question could not be decided until harvest time next year. Unfortunately, circumstances prevented me from being present at that time, and I had to depend for the result upon the report of my agent, in whom, however, I have great confidence. He reported that he gathered the wheat from small and perfectly equal portions of the two divisions, of which one had, and the other had not been ashed; finding no such difference between the two ashed portions as to render it worth while to distinguish them. On separating and measuring the wheat, he found that the quantity from the ground where the ashes were used was about double that from the part which had been supplied with muck alone, and, in relation to general productiveness, was in the proportion of about 27 bushels to the acre, far exceeding the ordinary crop, which, though under peculiarly favorable circumstances, it may sometimes equal 20 bushels to the acre, does not often, according to my experience and observation, exceed 12 or 15 bushels. It should be mentioned that the ground on which the experiment was made was of nearly equal quality throughout, and very poor.

But I have to mention a fact connected with these proceedings, which goes still further than anything yet said to prove the efficacy of potash in the wheat culture. The common poke is a plant abounding in the salts of potassa, and, therefore, selects for its own growth new and rich soils, which have not yet been exhausted by cultivation. Upon the heaps of swamp muck, thrown up on the borders of cranberry meadows in the process of their preparation, the poke springs up very rapidly and copiously, so as in a short time to completely cover the heaps; and the eye at once recognizes a muck bed by this luxuriant covering. By gathering and burning this copious crop, we obtained a quantity of ashes remarkably rich in potassa, containing at least 45 parts of the alkali in 1000 of the ashes, and therefore very nearly equaling in this respect the growing wheat. To test the quality of some ashes thus obtained, we substituted it for the common wood ashes in a small space of that division of the ground which was treated with this material. Within this small space the wheat grew most luxuriantly, with stems higher and stronger, and heads longer and fuller than those of the plant in other parts of the lot; and, when the crop was gathered, the produce was found to be in the proportion of thirty-eight bushels to the acre, exceeding by more than one-third that obtained under ordinary wood-ashes. As the proportion of the alkali in the two kinds of ashes used was the only point in which they materially differed, the necessary inference is that the difference in the amount of product was owing exclusively to

the much greater proportion of potassa in the poke-ashes, which exceeded by more than 20 times that of the wood-ashes; and further, that all the effects of ashes in promoting the growth of wheat are ascribable to the alkali contained in them.

These experiments were made on too small a scale, and with too little precision in quantity and measurement, to authorize any very exact conclusion as to the effect of ashes upon growing wheat; but they are sufficient, I think, to prove that the effect is very great, and that the farmer may have recourse, with great hopes of advantage, to this agent, if attainable at a suitable price. If the plan be generally adopted, the ashes would soon fail; but I have no doubt that commercial potash might be substituted for them, with at least equal effect; one pound of it being equivalent, I presume, to about a bushel of the best wood-ashes. Should the supply of commercial potash fail, recourse may be had to the alkali as now procured from mineral sources, which will probably prove inexhaustible.

A few remarks on the mode of using the ashes, or their alkaline substitute, for the promotion of the wheat crop, may be acceptable to those who, without previous experience, may be disposed to try the measure.

When leached ashes have been used as a dressing for wheat, for which experience has long showed that they are among the best fertilizers, they have been applied in the same manner as ordinary manure; being first spread upon the surface, and then turned under by ploughing. This method is correct; because the very small proportion of potassa contained in leached ashes is in the form of the insoluble silicate, which cannot be dissolved or carried away by the rains, but which is probably slowly converted, as wanted, into the soluble carbonate by the influence of the rootlets, which then absorb it. The unleached ashes, containing the alkali in a soluble state, cannot be treated in the same manner; as their alkali would be dissolved by the rain, and carried away, in great measure beyond the reach of the roots. I have, therefore, caused the ashes to be sprinkled or otherwise spread, as equally as possible, over the surface of the ploughed ground at the same time that the wheat is sowed, and the two then to be harrowed in together. The grain is thus brought into contact with the ashes, and, when the alkali is dissolved out, is ready to appropriate it to its own development. But as all the unappropriated alkali is probably dissolved out, and carried away by the winter rains, I direct that, in the early spring, another coating of ashes should be sprinkled over the young wheat, so as to yield it a supply of the alkali during the growing period.

The same plan, essentially, should be followed in the use of commercial potash. Being extremely soluble, it should first be dissolved in water, and the solution then sprinkled over the ploughed ground at the sowing of the wheat, and again in the early spring upon the crop as it is beginning to grow.

As to the precise quantity of ashes or of commercial potash to be

used, in proportion to the extent of ground, I am not prepared to say; but I believe that I have employed from 25 to 50 bushels of the fresh wood-ashes to the acre. I have no doubt, however, that this quantity might be greatly exceeded, not only safely but with advantage; as shown by the effects, before mentioned, of the poke ashes, which must have been equivalent in alkaline strength to at least 20 times the quantity of common unleached ashes.

Every farmer, in whose family the ashes are lixiviated for the preparation of soft soap, has it in his power to make a little experiment, the result of which may determine his future course. Let him beg from the women a bucket full of lye, and, after sowing his wheat in the autumn, let him, by means of a tin watering can with perforated spout, sprinkle the liquid equally over a small portion of the field, and repeat the process upon the same plot of ground when the wheat begins to resume its growth in the spring. If he find the product of the small plot thus treated greatly in excess of the average of the field, he may gain confidence to proceed on a larger scale, and thus perhaps, materially advance his income.

Within about a year, my attention has been attracted to the potato crop, with reference to the use of fresh ashes in its cultivation, and I have little doubt that the same treatment may be applied to this as to the wheat, with at least equal advantage. On consulting the chemical authorities, I found that the stems and leaves of the common Irish potato are even richer than the wheat plant in the salts of potassa; their ashes containing 55 parts of potassa in the 1000, while the proportion of wheat is only 47. Now the potato crop has of late years, in my neighborhood, been much more uncertain than formerly; even, I think, independently of the disease which has from time to time made so much havoc with this crop. It is highly probable that the cause, as in the case of fruit trees, may be a deficiency in the supply of potassa, and it is not impossible that the disease which is believed to have its origin in a microscopic fungus, may, like the worm at the root of the peach, depend upon the deprivation of the alkali, which may be necessary to the protection of the plant against these low parasites. To determine this point, as far as a single observation could do so, I had a quantity of potatoes planted last spring in rows, a certain number of which were supplied with fresh ashes in the hills, while the remainder were treated only with manure. In the rows in which ashes were used, the plant grew much more vigorously than in the others, and the product in potatoes was, I believe, about double; though I cannot recall the precise figure, in this case.

I have under way, this season, an experiment on the application of fresh ashes to the wheat crop on a much larger scale than the first; and my intention is to pursue a similar plan with the potato, at the time of planting in the spring. Should I be spared to see the results of these trials, I hope to be able to present a statement about them to the Society. Should the opportunity offer, I intend also to try how facts will support my

supposition, in relation to the use of common potash as a substitute for ashes.

I cannot close this communication without referring to the original subject of the revival of prematurely failing peach trees. I have continued to apply ashes in the same manner as at first, in the autumn or spring, or both, to the different kinds of fruit trees; and, I believe, with uniformly favorable results. The peach orchard, which, four years ago, appeared to be in a dying state, and had for several seasons ceased to bear fruit, is now in a vigorous state, and last summer yielded a copious crop. The old apple orchard, which was so wonderfully revived two years since, continues apparently, except in the case of a few trees dying from old age, to hold all that it had gained, though we lost the crop last year through the destruction of the blossoms by a late frost. The pears and quinces of which the blossoming period differed from that of the apple, so that they escaped the frost, were full of fruit; and I was particularly struck with one old quince tree, which, before the use of ashes had borne scanty crops of a small, imperfect, knotty fruit, but, last year, under the influence of ashes, was loaded with smooth and well formed quinces.

I have not yet been able to form any positive conclusion in relation to the protective effect of fresh ashes against the curculio in the plum tree; but I am prosecuting some inquiries in this direction, and hope before long to be able to solve the question either favorably or unfavorably. I must confess, however, that I am by no means sanguine of the former result.

ON THE FAMILIES OF FISHES OF THE CRETACEOUS FORMATION OF KANSAS.

By E. D. Cope.

(*Read before the American Philosophical Society, January 5th*, 1872.)

SAURODONTIDÆ.

Cope. Proc. Amer. Philos. Soc., 1870, p. 529. Hayden's Survey, Wyoming, etc., 1871, p. 414.

A considerable accession of material belonging to several species of this family, furnishes important additions to our knowledge of their structure, and enables me to determine their affinities with more precision than heretofore. The results are of value to the student of comparative anatomy, and also to the palæontologist, as they appear to have been the predominant type of marine fishes, during the cretaceous period, in the North American seas, and to have been abundant in those of Europe.

The characters already assigned to the family are confirmed by the new species discovered, and many additional ones added, as follows:

The cranial structure cannot be fully made out, but the following points may be regarded as ascertained: The *brain case* is not continued between the orbits, and the basis cranii is double and with the muscular tube

open. A large lateral cavity is enclosed by the proötic, the pterotic, the epiotic, etc. There are no exoccipital condyles, and that of the basioccipital is a conic cup. The pterotic and postfrontal are well developed. The ethmoid is well developed and slightly narrowed at its anterior extremity. The parasphenoid is narrowed and elongate; the vomer is continuous with it and is slightly expanded and then contracted at the anterior extremity: neither it nor the parasphenoid support teeth in any of the known genera.

The premaxillary bones are short, and form but a small portion of the upper jaw. The maxillary is elongate and simple. The hyomandibular is rather narrow and does not present an elongate peduncle for the operculum. The symplectic is well developed, entering far into the inferior quadrate. The latter is a broad bone, largely in contact with the metapterygoid, which is itself a thin plate, not probably attaining the pterotic. The superior branchihyals are short rods.

The relations of the supraoccipital, parietals, frontals, etc., cannot yet be satisfactorily made out, owing to the obscurity of the sutures. Nevertheless the following points may be regarded as probably reliable. The frontals have a rather broad union with the ethmoid, and are separated by suture throughout their length. They do not extend much posterior to the orbits and are succeeded by a rather narrow pair of bones which extend to above the *foramen magnum*. These are not united by suture, but present thickened smooth edges to each other, and appear therefore to have been separated by a fontanelle. Each is separated by serrate suture, from a broad lateral bone which is perhaps the pterotic, and certainly includes that element, as it supports the hyomandibular. It is not easy to determine what relation the median bones bear to the supraoccipital, but the structure looks a good deal like that characterizing the *Siluridæ*, or, considering the large pterotics, like the *Mormyridæ* plus the fontanelle. The shorter form of the pterotic in the *Characinidæ* and the *Catostomidæ* causes considerable difference in their appearance. There is no indication of fontanelle between the frontals in *Portheus*.

Portions of the scapulæ of *Portheus molossus* and other species, are preserved. They have very stout articular surfaces, and although not complete, have enclosed, more or less, a very large fontanelle. The superior surface is the larger, and is followed below by two others, the upper subvertical and small, the lower larger and transverse. These are surfaces supporting two basilar elements of the pectoral fin. There were perhaps three basilars, but the base of the coracoid displays no surface for articulation of a third. The suture with the coracoid crosses immediately below the lower condyloid surfaces, and passes just below the scapular fontanelle, leaving in the specimens a fractured surface which probably supported a præcoracoid. There are two fractured bases of the coracoid, which probably unite below, enclosing a foramen. On the scapulo-coracoid suture just within the space between the two inferior condyles is a smooth hemispherical pit of considerable size. Just in front of it is another of crescentic form.

A partially complete circle of bones convex on one side, concave on the other, was found with the remains of two species of *Portheus* and one of *Ichthyodectes*. They look like a *sclerotic ossification*, and as though moulded on a globe. They are not segmented as in Reptilian sclerotic ossifications, nor do they seem to have been completed circles.

The *femoral bones*, or those supporting the ventral fins are preserved in *Ichthyodectes anaides* and a *Portheus*. They are closely united posteriorly, the inner margins gradually approximating to the union, which is accomplished by the application of the subcylindric posterior part of the bones. In *Portheus* they are united by a coarse suture. There are no posterior processes, but the anterior are long and slender. Each is divided, the inner portion being rod-like; the exterior plate-like. The outer is probably the shorter; exteriorly it rises into an obtuse ridge on the lower side, and the plate then expands backwards as well as outwards nearly enclosing a large sinus with the base of support of the fin. The fin-supporting surface is sub-round, with two exterior and one interior articular surfaces, and a projection in the middle, which has one or two articular faces of smaller size. The base of the anterior projections is rather broader in *Ichthyodectes* than in *Portheus*.

Three kinds of *spine-like rays* or supports of the fins have been found in connection with remains of species of this family, and the proper reference to their positions and species is as yet in some degree uncertain. First. The elegantly segmented compound rays originally referred to *Ptychodus* by Agassiz, and described by me under the species *Saurocephalus thaumas*, appear to be referable to the genus *Portheus*, and to be supports of the caudal fin.* Secondly. Spines composed of unsegmented rays closely united edge to edge, and arranged like the fulcra at the base of the external rays of the caudal fin of recent fishes. That is, the first very short; those succeeding, increasing very regularly in length to the last, which forms the apex of the spine. The obliquely truncated extremities of these rods form a continuous sharp edge, which is coated with enamel, and may be straight, or interrupted with low knobs. The former kind belongs probably to *Portheus* and the latter to *Ichthyodectes*. It is nearly related in character to the spines of *Edestes*, the enamel coated knobs of *Ichthyodectes* rising into veritable teeth in the carboniferous genus. These spines are unsymmetrical, and belong either to the pectoral or ventral fins. To which they should be referred, it is not now easy to decide. The living allies of the *Saurodontidæ* do not possess ventral spines, nor do they exist in Physostomous fishes. In the *Siluroids*, the pectoral fins are supported by strong spines, which remotely resemble the present ones in their compound character.

Third. There are numerous flat, more or less curved, spines or rays, of small diameter compared with the length. One surface is covered with a thin, generally striate-grooved layer of enamel, and one edge is trenchant. One side of this edge is more or less obtusely rugose, or thickened.

* See Hayden's Report, *l.c.*, *p.* 423, where this view is held.

These rays thin out to the extremity, which in some cases at least is not contracted. These rays are composed of appressed halves, are unsymmetrical with basal hook, and belong no doubt to paired fins. If those already described are pectoral, these are ventral, and *vice versa*. A series of them found together had much the form of either of these fins, while their number would identify them with the ventral. In the rays found together, the first only had a trenchant outer margin, while several had a rabbet along one side of the posterior margin. I have already described such a spine as pertaining to the pectoral fin of *Ichthyodectes prognathus*.

The *vertebræ* in all the species certainly assignable to this group, are where known, deeply two-grooved on each side, besides the pits for the insertion of neurapophyses and pleurapophyses, except in the cervical region where the lateral grooves are wanting. There are no diapophyses. The caudal vertebræ are rather numerous but not so much so as in *Amia*, nor are they so much recurved as in that genus.

Until the structure of the posterior cranial roof and of the scapular arch are fully made out, it is premature to state precisely the affinities of this family. So far as known they are *Isospondyli* with some characters of the *Salmonidæ*, and some of other significance. The large foramen behind the proötic bone is more *Clupeoid* in character. The femoral bones are more like those of the *Plectospondyli*, dividing in a measure characters of the *Cyprinidæ* with those of the *Mormyridæ*. The vertebræ are Clupeoid, while the mode of implantation of teeth is peculiar.

Synopsis of Genera.

I. Jaws without foramina on the inner face of the alveolar margin.

Teeth of unequal lengths in the maxillary and dentary bones..*Portheus*.

Teeth of unequal lengths, cylindric.....*Ichthyodectes*.

II. A series of foramina on inner side of alveolar wall.

Teeth with sub-cylindric crowns.....*Saurodon*.

Teeth with short compressed crowns.....*Saurocephalus*.

There are some other forms to be referred to this family, whose characters are not yet fully determined. Thus *Hypsodon Agass.*, from the European chalk is related to the two genera first named above, but as left by its author in the Poissons Fossiles, includes apparently two generic forms. The first figured and described, has the mandibular teeth of equal length. In the second they are unequal, as in *Portheus*, to which genus this specimen ought, perhaps, to be referred. Both are Physostomous fishes, and not related to the *Sphyrænidæ*, where authors have generally placed them. Retaining the name *Hypsodon* for the genus with equal mandibular teeth, its relations to *Ichthyodectes* remain to be determined by further study of the *H. levesiensis*.

A species of *Ichthyodectes*, from the chalk of Sussex, England, is figured but not described, by Dixon, in the Geology of Sussex.

A number of forms, erroneously referred by Agassiz and Dixon, to the genus *Saurocephalus*, have been referred by Leidy to a genus he calls

Protosphyræna,* with two species, *P. ferox* and *P. striata*. The latter much resembles a *Saurocephalus*, having equal teeth; while the former probably includes several species, and possibly genera. The teeth first referred to it resemble those of *P. striata*, while others resemble those of *Portheus*. An examination of the figures of the mandibles of the last in Dixon's work, show that the large and small teeth occupy different areas, separated by grooves in a manner quite distinct from anything seen in *Portheus;* but, should it prove identical, it can scarcely be regarded as typical of *Protosphyræna*, which name, moreover, has never been accompanied by the necessary description.

Dr. Leidy applied the name of *Xiphactinus* to a genus indicated by a spine, in some degree like those regarded above as ventrals of *Saurodontidæ*. It is quite distinct from those assigned to *Portheus* and *Ichthyodectes*, and may belong to *Saurocephalus*, as already suggested, or to another genus.

PORTHEUS. Cope.

(*Proceed. Amer. Philos. Soc.*, 1871, p. 173.)

Teeth subcylindric, without serrate cutting edges, occupying the premaxillary, maxillary and dentary bones. Sizes irregular, the premaxillary, medium maxillary and anterior dentary teeth much enlarged. No foramina on inner face of jaws. Teeth on the premaxillary reduced in number. Opercular and preopercular bones very thin. Cranial bones not sculptured.

The fishes of this genus were rapacious, and, so far as known, of large size. They constitute the most formidable type of Physostomous fishes known. Three species are known to the writer, one from teeth only, from the Miocene of North Carolina, but not certainly known to be an intrusive cretaceous fossil; and two from Kansas. The latter are represented by more or less numerous fragments of eleven individuals, three of which possess large portions of the cranium, one almost entirely complete. Two of the remainder embrace jaws, and one a large part of the vertebral column, with segmented rays. In one, these rays were found with the cutting compound ray above described; while the simple flat ventral rays occur with several specimens. In none have any traces of symmetrical spinous rays been found, nor strong interneurals capable of supporting such. In none of the more perfect specimens with crania have the segmented always been found, but the fossil of *P. thaumas*, where they occur, is represented by a vertebral column and its appendages, which do not differ appreciably from those of *P. molossus*.

In the *cranium* of this genus, there is a well-marked supraorbital rim. Each opisthotic forms a prominent angle, directed posteriorly on each side of the exoccipital. The parasphenoid is a stout and narrow bone, deeply emarginate behind, for the passage of the muscular canal. It has a transverse expansion in front of the base of the proötic, which rests on a backward continuation of the same. This expansion is pierced behind

* Trans. Amer. Philos. Soc., 1866.

by two round foramina. The shaft is abruptly contracted in front of the expansion, and is trigonal in section. The prefontal extends downwards and forwards, and carries inferior and anterior articular faces; the latter vertically transverse. The postero-inferior portion of the ethmoid bears on its posterior extremity a concave articular face, which opposes that of the prefrontal. The floor of the brain-case in front is supported by a vertical style, which is bifurcate above, and rests on the parasphenoid.

Of the *teeth*, in general, it may be added that their pulp cavity is rather large at the base, but rapidly diminishes in the crown. The mode of succession is by direct displacement from below. The young crown rises into the pulp cavity, and destroys the vitality of the crown, while the root is absorbed. Numerous empty alveoli are to be found in all the jaws of this genus, in which examination will often detect the apex of the crown of the young tooth.

The *vertebræ* in this genus are rather short, but not so much so as in sharks. In *P. thaumas*, nearly eighty dorsals and caudals were preserved; those without lateral grooves, or cervicals, are not numerous. There are, perhaps, not more than four vertebræ supporting the caudal fin, though this is difficult to determine, owing to the concealment of the terminal centra by bases of radii. There are seven hæmapophyses in the support, all flat except the first, which is like those anterior to it. The second is articulated freely to its centrum, and is wider than the others. Its condyle is characteristic, being double, and with a foramen between it and the produced extremity of posterior margin of the bone. It is slightly separated distally from the third, but the remainder are in close contact. The radii of the superior lobe of the caudal fin extend at least as far down as near the end of the third haemal spine from below. The structure of these parts in the *P. molossus*, are as in *P. thaumas*, so far as preserved.

As some of the *spines* are not referable to their precise species in this genus, they may be described here. A large compound spine found in the blue limestone shale in Fossil Spring Cañon, is composed at the base of about twenty-six narrow double rods. A few appear between the others beyond the base making thirty-one altogether. They are very oblique to the general base, but curve so as to become nearly straight, and enlarge distally. They terminate in a thickened portion which bears an acute edge, which truncates them obliquely, forming the cutting edge of the spine. This portion is enamelled; the edge is slightly convex at the base, and slightly concave at a point probably beyond the middle.

	M.
Length of fragment (12 inches)	0.30
Width at base	.12
Thickness at base	.012
Thickness at broken end an inch from edge	.007

This is a formidable weapon and could be readily used to split wood in its fossilized condition.

The third form of spine is represented in most of the species, but one series of rays with spine may not be referable to any of them. The latter is flat and curved, the convex edge trenchant beyond the middle. The posterior edge is obtuse but narrow, and exhibits a slight groove on one side medially; proximally there is a shallow rabbet whose floor is transversely rugose. Several layers of the tissue of the spine beyond the basal portion are delicately longitudinally striate. The distal half is broken away; length of fragment, one foot; width, 1.5 inches; thickness at middle, 5 lines.

The species of this genus may be distinguished as follows:

a, Teeth without acute edges.

Large maxillaries five; second premaxillary larger than the first; third mandibular large, behind a cross-groove; last large mandibular followed by 16,—8 small teeth.....*P. molossus.*

Large maxillaries, three; first premaxillary larger than second; third mandibular small, no cross-groove in front of it; twenty small teeth behind last large mandibular.....*P. thaumas.*

aa, Large teeth with cutting angle in front.

Teeth large, not compressed.....*P. angulatus.*

PORTHEUS MOLOSSUS. Cope.

(Proc. Amer. Philos. Soc., 1871, p. 173.)

Represented by four individuals, one from Fox Cañon, near Fort Wallace, with complete cranium, and many vertebræ and radii; a second from another part of the same ravine with large part of cranium, and a third and fourth from lower Butte Creek bluffs, both with fragments of cranium and other portions. In the first specimen the jaws are perfect and dentition complete.

The *premaxillary* is vertically oval, convex externally, nearly flat within, and more than half underlaid by an anterior lamina of the maxillary, The anterior or median margin is regularly convex and exhibits no surface or suture for union with the bone of the opposite side. Its posterior margin extends obliquely backwards to beneath the superior articular condyle of the maxillary and has a ragged margin, though the suture is squamosal. Its superior margin is deeply inflected in front of the condyle and then convex and thickened. The anterior margin is thick and rugose with tubercular exostoses. There are but two teeth, which are very large, and directed obliquely forward; the first is two-thirds the diameter of the second.

The *maxillary* is a large laminiform bone, with the upper margin considerably thickened proximally but much thinned distally. It is abruptly contracted at the distal two-thirds its length, apparently for the attachment of a supernumerary bone. The extremity is curved sabre-shape upwards, and has an acute toothless edge. The teeth are, four small, five large, and eighteen small. These teeth, except the largest, have cylindric bases; the crowns (and bases of the latter) are slightly compressed or

oval; they are straight and regular, and lean backwards. The middle one of the five is largest, being six times as long as the small ones, but little more than half as long as the large premaxillary or mandibular. The surface of the maxillary is rugose with small tubercles on its lower half, and has shallow grooves for nutritious vessels running downwards and forwards.

The *mandibular rami* are short and deep, and have but little mutual attachment at the symphysis. They are not incurved at that point, and were bound by ligament only. There is no coronoid bone and the articular is distinct. It is short, of a rather irregular wedge shape, and supports half the cotylus, above which it sends a short acuminate process. The angular has a prominent angle, like half an ellipse somewhat contracted at the base; below it has a rough prominent muscular insertion. The bone extends in a long sword-shaped process, on the inside of the ramus to beyond its middle; externally, it is soon covered by the thin truncate edge of the dentary. This element is very large. From the angular it rises steeply to a coronoid process, which has a slight outwardly twisted eminence, and then follows a gently concave line to the symphysis. The teeth are as follows: two large, a transverse groove; three large, four very small, nine medium, and two very small; total twenty. These teeth have straight cylindric-conic crowns, with enamel without striæ or facets. The larger are a little compressed.

Measurements of Jaws and Teeth.

	M.
Length premaxillary bone	.007
Depth " "	.093
Thickness on alveolar margin	.016
Length crown of second tooth	.046
Diameter do. at base	.014
Length maxillary bone from premaxillary	.270
Depth " at condyle	.08
" " at middle	.046
Length crown third large tooth	.028
Diameter do. at base	.011
Length crown second small tooth from large	.006
Diameter do. at base	.004
Length ramus mandibuli	.350
" of angle	.04
" of angular bone anteriorly	.08
Depth at coronoid process	.112
" at fourth tooth	.08
Length crown first tooth	.038
Diameter do. at base	.011
Length crown fourth tooth	.055
Diameter do. at base	.016

The *opercular bones* are thin; the operculum broad, the preoperculum

rather narrow. The latter is without armature, and has some depressed grooves radiating towards the circumference. Length of bone vertically, M. .245; radius from inner curve, .09.

The *vertebræ* display deep lateral grooves; articular faces smooth. Length centrum, M. .028; diameter, .043. The fan-shaped hæmal spines, or second of the caudal fin is like that of *P. thaumas*, but smaller. The last caudals contract in size very rapidly; the cup of the penultimate or last is transverse diamond shaped.

The fragments of the sabre-shaped *spine* display several layers of parallel striate dense bone, and the edge is tubercularly dentate, and one side is much more rugose than the other. At the base, one side is flat; the other convex, and there is a transversely rugose band near one edge.

The *scales* are thin and cycloid, and though large are not remarkably so for the size of the fish.

Measurements of Cranium.

	M.
Length from angle of opisthotic to anterior extremity of ethmoid	0.30
Length from same to front of proötic	.11
" " postfrontal to prefrontal across orbit	.11
" " occipital condyle to transverse process of parasphenoid	.117
Length from do. to bottom parasphenoid emargination	.055
" parietal bone on outer suture	.07
Width do. at middle	.014
" do. to edge pterotic	.07
" frontal at middle orbit	.04
" parasphenoid do.	.03
Length inferior quadrate	.10
" condyle of do.	0.03
" symplectic	.064

The gape of the mouth of the *Portheus molossus* extended the whole length of the cranium proper, and far beyond the orbits, since the maxillary reaches to opposite the occipital condyle. The orbits were large. The lower jaw was deep, and gave the countenance that bull dog expression from which it derives its name. The body was short or moderately elongate. As materials for a restoration of this fish exist, I will give one at a future time.

PORTHEUS THAUMAS. Cope.

(*Saurocephalus thaumas*, Cope. Proceed. Amer. Philos. Soc., 1870, November. Hayden's Survey, Wyoming, etc., 1871, p. 418.)

This large species rests on a specimen without cranium, originally procured by Professor B. F. Mudge. The parts preserved are not distinguishable from the corresponding ones in two individuals obtained by myself in Western Kansas, which include the greater portions of the jaws

and suspensorial apparatus. These indicate larger animals than those of *P. molossus*, and probably indicate the most powerful of the Physostomous fishes, equaling in this respect many of the saurians which were their contemporaries.

The distinguishing features of the species have been already pointed out.

The *premaxillary* is an obliquely oval bone or subpentagonal; the suture with the maxillary is not toothed, and the anterior or free edge is smooth, not tubercular as in two specimens of *P. molossus*. There are but two teeth, of which the anterior is immense, and the second little more than half its diameter. The *maxillary* is stout, and supports in front four very small teeth, then three very large, of which the median is largest. The teeth recommence very small and closely placed in the same line; but as the extremity of the maxillary is lost, the number cannot be stated.

The *dentary* is similar in form to that of *P. molossus*, but has rather more numerous teeth. Counting from the front there are two large, one rather small, two large, and eighteen small and medium following, the smallest from third to ninth, inclusive. None of the crowns are preserved, but the alveoli are round or nearly so. The large tooth of the premaxillary if proportioned as in *P. molossus* must have projected M. .0755, or three inches above the alveolus; the fourth mandibular was but little smaller.

Measurements of Jaws.

	M.
Length premaxillary	.075
Depth "	.09
Depth maxillary at condyle	.08
Thickness " just behind condyle	.025
Length dentary	.25
Depth " at symphysis	.08

The various portions of *cranial bones* preserved are much like those of *P. molossus*, but stouter. The hyomandibular is nearly perfect: it is thin, but has a convex rib extending to its acuminate extremity at the posterior-inferior angle of the metapterygoid and the superior extremity of the symplectic. The preoperculum is attached by a thickened grooved margin, and is not overlapped by the hyomandibular. It extends in a curved form round towards the angle of the inferior quadrate. Three elongate bones, closely appressed, I suspect to be part of this bone, with interoperculum and superior ceratohyal. The last is rather narrow, and with smooth distal articular surfaces, without suture. The superior branchihyals are a little like phalanges of Mosasaurus in form, being sub-similar and expanded at the ends, and quite alternated. The parasphenoid is similar to that of *P. molossus*. The position of the hyomandibular is vertical to the axis of the basioccipital; the superior part directed forwards.

	M.
Length basioccipital to end muscular foramen	0.077
" hyomandibular	.26
" inferior quadrate (oblique)	.113
" condyle of quadrate	.036
" preopercurlum preserved	.035

A portion of one of the flat unsegmented spines preserved exhibits an irregular rabbet on each edge of one side; width, .042 M. The sclerotic bones are as already described.

A second specimen is still stouter in proportions, as the following measurements show:

	M.
Diameter maxillary condyle,	.034
Diameter maxilla above, behind condyle	.033
Length angle jaw (exteriorly)	.056
Diameter parasphenoid at middle of preötic	.03
Diameter dorsal vertebra (crushed)	.067

The diameter of the vertebra must be a little corrected by reduction.

The largest fish vertebræ obtained may be here mentioned. They are peculiar in having numerous concentric grooves on the articular faces, as in *Ischyrhiza*. They are otherwise as in this genus. Length, M. 04; diameter, .062.

A peculiarity of *dentition* is observable in the two specimens first described, and in less degree in *P. molossus*. A considerable number of alveolæ support no functional teeth (though included in the enumeration), but are occupied at some point by successional teeth. In some cases the mouth of the alveolus appears to be narrowed by ossification, even where the tip of the young tooth is in sight; in one case so far developed as to close up to the projecting apex. In other cases the orifice is entirely stopped by the ossification, which presents the appearance of a scar, with radiating lines of pores.

The type specimen was discovered in a denuded area among the lower bluffs of Butte Creek. The flat cranial and jaw-bone occupied the summit of a cone of twenty or more feet in height, a relic of the ancient blue limestone spared from the surrounding denudation. The flat bones had shed off the water, which, running off on all sides, had formed the cone. The second specimen came from the Fossil Spring Cañon, near the remains of *Liodon curtirostris*.

Portheus angulatus. Cope.

The crown of the tooth which indicates this species is slender, compressed, and curved backwards, and a little inwards. The circumference is divided by two edges, the anterior acute, the posterior obtuse; the convex faces separated by these are not equal, that towards which the crown is curved laterally, *i. e.*, the inner, being somewhat more extensive, and considerably more convex.

Enamel smooth, without sculpture; anterior cutting edge without crenations, more curved backwards than the posterior, which has but little curvature. Inward curvature slight.

	Lines.
Diameter (anteroposterior) at middle crown	5
" transverse at middle crown	4
" " near tip	3
" anteroposterior, near tip	2

Discovered by Prof. C. Kerr, State Geologist of North Carolina, in the Miocene marl, Duplin Co., North Carolina, with Polygonodon rectus, and Ischyrhiza antiqua, Leidy.

ICHTHYODECTES. Cope.

(*Proceed. Amer. Philos. Soc.*, 1870, *Nov. Hayden's Geol. Survey, Wyoming*, etc., 1871, p. 421.)

Teeth equal subcylindric, in a single row, sunk in deep alveoli. Premaxillaries short. No foramina at the bases of the teeth on the inner alveolar walls. Vertebræ deeply grooved laterally.

The species of this genus are, so far as known, smaller than those of the last; and as their remains are more perishable than those, they form a less striking object among the fossils of Kansas. They are nevertheless, very abundant, especially in species, five of which are now described. In originally describing this genus, the vertebræ were regarded as not grooved, in consequence of such vertebræ having been discovered along with the bones and teeth of *I. ctenodon*. Further examination has satisfied me that this union is erroneous, and that the bones, if found together, were accidentally so.

Spines similar to those of the *Porthei*, but presenting certain differences, may be referred to this genus. The compound segmented spines cannot be ascribed to it, but the compound fulcrum-like spines are similar, though composed of fewer and stouter rods. Each of these, as it terminates at the cutting edge, give rise to a projection, giving it an obtusely and remotely serrate character. It is rugose with enamel deposit, and constitutes as effective a weapon of defense as that of *Portheus*. One, which is nearly perfect, contains fifteen pairs of rods, which expand at the base, as do the rays of a pectoral fin. Total length, M. .235; width, at base, .04; thickness beyond base, .006.

The femoral bones have already been described. The maxillary is not contracted at the end for a supernumary bone, as in *Portheus*.

The form of the inferior quadrate is like that of *Portheus;* in *I. anaides*, the groove for the preoperculum extends low down, and the symplectic has a wider exposure on the outer face than in *Portheus*.

In a series of vertebræ similar to those of this genus, those included in the basis of the caudal fin are not more than three in number.

The species are distinguished as follows:

Premaxillary teeth five; second most prominent; maxillary not concave; dentary with 30 teeth and bi-convex alveolar border, with obtuse extremity..... *I. anaides.*

Premaxillaries (?); maxillary straight, large, with 40 teeth; dentary straight, not produced at end; teeth 26.... *I. ctenodon.*

Premaxillaries five; first most prominent; maxillary, narrow concave; teeth small; dentary with a hook at apex; teeth 25..... *I. hamatus.*

Premaxillaries seven; first most prominent, compressed; smaller..... *I. prognathus.*

Premaxillaries twelve; second most prominent, the bone much narrowed above; smaller..... *I. multidentatus.*

The English species of this genus is figured by Dixon in the Geology of Sussex, pl. xxxii.*, figs. 9 and 9*. I can find no letter-press or name relating to it, and cannot determine its specific characters from the fragmentary character of the piece of mandible figure.

ICHTHYODECTES ANAIDES. Cope. sp. nov.

Indicated by two individuals, one with both dentary bones and teeth, with vertebræ, the other with many portions of cranium, fin rays, vertebræ, and other elements more or less separated. The latter were all taken from the upper face of a spur of a limestone bluff, elevated about five feet from the ground level, where they were denuded and exposed as on a table, prepared for the use of the geologist.

It is the largest species of the genus, and the anterior premaxillary teeth are larger than the posterior. The *premaxillaries* are oblique ovoids, very convex on the external face, thinning laterally and above. The superior margin presents a thickening, bearing an articular surface, while behind it is an open gutter-like inflexion. The large teeth are quite cylindrical. Both these bones are preserved. But part of the right *maxillary* remains. It is thickened above in front of the condyle and is regularly convex at that point. The teeth are small, there being 10.5 in an inch. The margin is not concave.

The mandibular rami are preserved almost entire. They are short and deep, and have a short angular process, which is relatively shorter than in *Portheus*. The margin rises steeply to the dentary, which presents a narrowed rectangle behind. The alveolar margin has two convexities with a depression between; the symphyseal angle is not prominent. The lower posterior angle of the dentary is quite prominent for muscular insertion. The crowns of the teeth are cylindric, slightly curved inwards. The dentary bones of the second specimen coincide with these in all respects.

Thirty-three *vertebræ* are preserved, all deeply two-grooved on the sides. The ribs are articulated by a sigmoid surface to a broad short element of a sigmoid form which is inserted in the lateral groove of the inferior face, or articulated by gomphosis.

The spines already noticed are quite flat, without serrate edge, but with some rugosities near the edge on one side only. There are no grooves on the upper side, but the dense bone is delicately striate; distally grooved.

Measurements.

	M.
Length premaxillary	0.033
Depth "	0.045
Depth maxillary at condyle	.037
Thickness " just behind condyle	.012
Length mandibular ramus	.172
" angular process	.014
Depth at coronoid process	.058
" " symphysis	.041
Length of eight vertebræ	.212
Width of articular face	.030
" " a rib	.004
" flat spine at middle	.025
Length " (fragment)	.155
" condyle inferior quadrate	.02

The scales associated with this species were thin and cycloid, and difficult to preserve.

From near the Smoky Hill River, Kansas.

ICHTHYODECTES CTENODON. Cope.

(Proc. Amer. Philos. Soc., 1870, Nov. Hayden's Geol. Surv., Wyoming, etc., 1871, p. 421 part.)

Found by Professor Mudge on the North Fork of the Smoky Hill River; common in many other localities.

ICHTHYODECTES HAMATUS. Cope. sp. nov.

Represented by a considerable number of remains of an individual from the blue cretaceous shale near Russell Spring, on the Smoky Hill River.

The characters which distinguish this species from *I. anaides*, are numerous, but they are less marked when compared with those of *I. ctenodon*, partly because the premaxillary bones of the latter have not been preserved. In the first place, the dentary bones of the two are of equal length and support the same number of teeth; it is concave at the proximal part of the tooth line, but is straight in the corresponding part of *I. ctenodon*. The end of the dentary is furnished with a strong obtuse process or hook, directed upwards and forwards, not seen in *I. ctenodon*. The maxillary behind the premaxillary is, in this species, thickened, and with two articular surfaces, the proximal looking outwards, the distal inwards and separated by an oblique ridge from the condyle. In *I. ctenodon*

there is but one smooth surface gradually narrowing with the thinning of the bone from the condyle.

The *premaxillary* is less extended antero-superiorly than in the species already described, but supports, as in it, an articular face. There is no groove behind it, as in *I. anaides* and *Portheus*. It displays a surface for osseous articulation to near its extremity on the inner side, while below it, and on the external face, near the basis of the first and second teeth, the surface is rugose; maxillary teeth 43. The dentary supports 25. The anterior hook is obtuse, and rises abruptly to above the apices of the crowns of the teeth. It is knobbed above, and supports a tooth not larger than the others.

All the cranial bones preserved are not sculptured.

Portions of the thin *flat spines* display the delicately-grooved striation already observed, while the trenchant edge is bordered on one side by raised *longitudinal* striæ. The other side is minutely pitted.

The vertebræ are anterior, and without lateral grooves. Three of them are M. .06 in length; an undistorted one is a little wider than deep, and the cup is .026 across.

Measurements.

	M.
Length ramus mandibuli	0.174
Depth at symphysis	.055
" premaxillary (oblique)	.043
Length " "	.026
Depth maxillary at condyle	.027
" " behind "	.033
" " near middle	.027
Width flat spine	.031

This species, and the two preceding, were not very unlike in size; the two following are smaller.

ICHTHYODECTES PROGNATHUS. Cope.

(Proceed. Amer. Philos. Society, November, 1870. (*Saurocephalus.*) Hayden's Geol. Survey, Wyoming, etc., 1871, p. 417.)

In this species the premaxillary is more rhomboid in outline than in the others, and is less convex externally. Of its more numerous teeth, the first is not larger than the last, differing thus from all others of the genus, and it is in line with the nearly straight anterior margin of the bone. It is more compressed than in the other species, whence I originally placed it in *Saurocephalus*. To this genus it does not belong, as the absence of marginal alveolar foramina shows. The surface of the bone is peculiar; in a minute sculpture of impressed lines, or lines of punctæ. There is a very small articular surface on the superior extremity.

From the North Fork of the Smoky River.

ICHTHYODECTES MULTIDENTATUS. Cope. sp. nov.

Here we have again the convex *premaxillary* of the larger species, with more numerous (12) teeth than in any other of the genus. These increase in size to the first three, the last being small. The second and third are about equally prominent, and more so than the first. The bone is much contracted above, there being an excavation on the anterior border and contraction from behind. The superior edge is thin, and *without trace of articular* surface. Alveolar edge somewhat rugose. The *maxillary* is both narrow and thin, but is only partially preserved. It bears five teeth on M. .01. One of these, with complete crown, displays a longitudinal angle on the antero-interior face.

No other remains were preserved.

	M.
Length of premaxillary	0.039
Depth " (oblique)	.023
Length of tooth line	.025

From near Fossil Spring, W. Kansas.

SAUROCEPHALUS. Harlan.

Leidy has pointed out the mode of implantation of the teeth in the typical species of this genus. The mode of succession of the teeth has not yet been indicated, but is well displayed in a specimen of the jaw of *S. arapahovius*, Cope. It is known, from Harlan's description, that a large foramen issues on the inner wall of the jaw, opposite each root. The fractured ends of the specimen exhibit the course of the canal which issues at this foramen. It turns abruptly downwards between the inner wall of the jaw and the fang of the functional tooth, and not far from the foramen. Its course is interrupted by the crown of the successional tooth. This is situated obliquely as regards the long axis of the jaw.

It is thus plain that, the successional appearance of teeth is different in this genus from what I have described in the two genera preceding. In them the foramen is wanting, and the young crown rises within the pulp cavity of the functional teeth, as in the *Crocodilia*. In this genus, on the other hand, it is developed outside of the pulp cavity and fang of the old tooth, and takes its place as in many *Lacertilia* and in the *Pythonomorpha*, by exciting the absorption of the latter. The obconic form of these fangs in *Saurocephalus* is appropriate to such a succession, and their great length seems to preclude the nutrition of the young tooth from their bases. The use of the foramina on the inner face of the jaw is thus made apparent, viz., the nutrition of the successional teeth from without. I cannot trace the canal below the crown of the young tooth to the base of the pulp cavity of the old tooth; and there are canals in the jaw, below the latter, one of which probably carried the dental artery.

Species of this genus are less abundant in the part of Kansas examined by me than those of the preceding genera. Two only have been observed up to the present time, as follows:

SAUROCEPHALUS PHLEBOTOMUS. Cope.

(Proceed. Am. Philos. Society, Nov., 1870. Hayden's Geology, Wyoming, etc., 1871, p. 416.)

Solomon River Region. Prof. Mudge.

SAUROCEPHALUS ARAPAHOVIUS. Cope.

Established on a portion of a maxillary bone, with a part of a suture, perhaps for attachment to a supernumerary maxillary. The size of the species is nearly that of *S. lanciformis*, and the crowns of the teeth are rather short, as in that species, and less elongate than in *S. phlebotomus*. The teeth are very closely set, and the alveoli are separated by very narrow septa. The crowns are expanded, so that the edges overlap in some cases. The form of these is much compressed, width about equal to height, the edges convex and acute. The enamel is smooth and without facets. The roots are without the facets, shown by Leidy to exist in *S. lanciformis*, and appear to be longer than in that species, exceeding the length of the crown nearly four times. None are, however, perfectly exposed for complete measurement. As usual, there is a large foramen opposite each fang, below the inner alveolar margin, and between the latter and the series of foramina the surface is slightly convex and minutely rugose.

	M.
Depth of bone	.035
Thickness at rugose band	.0055
Total length of a tooth (?)	.02
Length of a crown	.0043
Width "	.0036
Number, etc., in an inch	8.

The size of this fish was probably about equal to that of *Ichthyodectes anaides* above described. Found loose on a cliff of blue shaly limestone, fifteen miles south of Fort Wallace, Kansas.

PACHYRHIZODONTIDÆ.

This family of Physostomous fishes differs from the last in the nature of its dentition. Instead of elongate conic fangs sunk in deep alveoli, it has shorter and stouter fangs occupying alveoli, of which the inner side and part of the anterior posterior walls are incomplete. The teeth are, in fact, more or less pleurodont, but the extremity of the root is received into the conic fundus of the alveolus.

The premaxillary bones are well developed, but the maxillaries are more so, and enter largely into the composition of the border of the mouth, There is a well-developed angle of the mandible, but no coronoid bone is preserved in the specimens. The coronoid region is, however, broken in all our specimens. The other characters of the family are not determinable from our imperfect materials.

PACHYRHIZODUS. Agassiz.

Dixon's Geology of Sussex, 1850, p. 374.

This genus was established by Prof. Agassiz, on a jaw fragment from Sussex, England, with a very brief description. The Kansas remains resemble this fragment in their corresponding parts, and I refer them to the same genus for the present.

The genus as seen in our fossils, is defined as follows:

Muzzle flat; premaxillary bones rather long, with two large teeth together, near the anterior end, behind the usual external series. Maxillary and mandibles with a single series of simply cylindric curved teeth. Mandibular rami closely articulated by ligament.

The teeth in this genus bear a superficial resemblance to those of a mosasauroid genus. Their mode of succession appears to be as follows:

The crown of the young tooth was developed in a capsule at the base of the crown, or on the inner side of the apex of the thick root. The absorption which followed excavated both the former and the latter, but the crown was evidently first shed. Finally, the old root disappeared, and when the new one occupied the alveolus, it left a free separation all round. Finally, on the accomplishment of the full growth of the root, it became anchylosed to the sides of the alveolus. The pleurodont position of the tooth facilitated the shedding of the root very materially.

The genus *Conosaurus*, Gibbes, from South Carolina, is, perhaps allied to this one. Its dentition is fully described by Leidy, who changes the name to *Conosaurops*, mainly on account of the inappropriateness of the Greek Σαυρος to a fish. This word was, however, employed by the ancients to designate a fish, and the only use made of the word out of composition, by modern zoölogists, is for species of that class, so that it does not seem improper to use it here.*

Three, perhaps four, species left their remains in the strata examined by the expedition.

PACHYRHIZODUS CANINUS. Cope. sp. nov.

Established on portions of, perhaps, two individuals, which embrace one nearly complete maxillary bone, two premaxillaries of opposite sides, two nearly perfect rami of the mandible, with numerous other portions in a fragmentary condition.

These indicate a cranium of about a foot in length, by six and a half in width, oval in outline, with moderately obtuse muzzle. The mandibular teeth are directed somewhat outwards; the premaxillary is horizontal in front, and the maxillary narrow. From these facts I derive that the head was probably depressed, as in the modern *Sauri*, and very different from the prevalent compressed form of the *Porthei* and allies.

* The case appears to me to be different with the name *Ischyrosaurus*, which I proposed to replace with *Ischyrotherium* (Leidy). The latter was given to a genus of saurians, under the supposition that it belonged to the *mammalia*, and the termination, *therium*, devoted to this group of animals by meaning and custom, cannot be applied to a sauriam by any stretch of metonymy or charity.

The *premaxillary* is several times longer than wide; posteriorly it is a subvertical plate; anteriorly it terminates in a narrow obtuse portion. Just behind this portion it is enlarged on the inner side, forming a knob, whose upper surface supports the articulation with the ethmoid. It bears the two large teeth below, on a common elevation of the jaw. The outer margin of the bone supports ten sub-equal teeth, which are one-third smaller than the posterior pair. The outer alveolar ridge is a little more elevated than the inner, though a little less so than on other bones which support teeth. The external face of the bone is nearly smooth, and the inner unites with the maxillary by striate squamosal suture.

The *maxillary* preserved is nearly perfect, and may belong to another animal; its depth coincides with that of the premaxillary. It is quite elongate, about nine times as long as deep, perhaps a little more. It supports forty-two closely packed teeth, not all in functional service at once. The distal end is contracted and grooved and ridged on the inner face, as though for union with a supernumerary bone. The external face is longitudinally striate on the posterior half, the striæ running out to the margins, forming sharp rugosities on the alveolar border. The superior (palatine) articular surface is more than one-fourth the total length from the anterior extremity; it is narrow and somewhat lens-shaped. Both behind and in front of it, strong striæ run from the outer to the inner side of the superior margin, sub-longitudinally. Posterior to the superior articular surface on the outer face is a swelling like a muscular impression, from which grooves and keel extend posteriorly. The bone is concave on the outer face in front, to accommodate the *os premaxillare*.

The *mandibular rami* are abruptly incurved at the symphysis, which is not serrate, is sub-round, with an emargination entering from the inner inferior side. The dentary bone is much narrowed behind. The *angular* bone extends anteriorly on the inner face to the end of the posterior, two-fifths of the dental line. The ramus is not very deep at the coronoid region. The articular cotylus is composed more largely of the angular than the articular. Its long diameter extends inwards and backwards, and is strongly convex; in the transverse direction, slightly concave. Below and in front of it the lower margin of the jaw is acute. The angle is oval and rather small, it is prominent on the middle line on the inner side, the edges are thin, the upper curved outwards, concealing part of the cotylus. There are twenty-nine teeth on the dentary, whose sizes diminish towards its extremities. Their roots are very large and longitudinally striate and porous. Opposite the interval between the first two teeth, there is a tooth exterior to the general row, and another on its inner side. They are not enlarged.

No *teeth* are preserved except on the maxillary. These are not very elongate cones, with round section, and well curved inwards. Dense external layer entirely smooth.

This species differs from the type *P. basalis*, Dixon, in that the radical portion of the tooth is less swollen, and more conic, and does not project above the exterior alveolar wall as in that fish.

Measurements.

	M.
Total length mandibular ramus	0.267
" of tooth line	.170
Transverse diameter of symphysis	.018
" " base of tooth	.004
Length premaxillary	.068
" " to large tooth	.01
Greatest depth "	.018
Diameter large tooth at base	.007
Length maxillary to first tooth	.171
Depth " at " "	.019
" " at last "	.014
" articular surface	.0245

Found by the writer near Fossil Spring, near Fort Wallace, in Western Kansas.

PACHYRHIZODUS KINGII. Cope. sp. nov.

Established on the proximal portion of a maxillary bone with the articular surface, and bases of twelve teeth. It is a species of nearly the same size as the last, but the bone contracts more rapidly than in that one, and presents a stronger interior longitudinal ridge. The superior articular face is smaller and narrower, being sub-crescentic, while the insertion-like tuberosity is nearer to it, and on the inner edge of the outer face, and connected with the articular face by a ridge, not separated by a groove as in *P. caninus*. The outer face is depressed below the articular face much more than in that species, so that its lower portion becomes more convex. The roots of the teeth are of the same length as in *P. caninus*, and as they are more numerous, they are more closely packed and more cylindric. Their pleurodont character is also more strongly marked. The superior surface of the bone is striate grooved longitudinally, and transverse or obliquely.

	M.
Total depth of bone at articular face	0.022
Depth at tenth tooth	.0155

This species was found near the preceding. It is dedicated to Doctor William Howard King, Post Surgeon at Fort Wallace, to whom, and not less to his excellent wife, I am indebted for hospitality and other assistance of a kind essential to the success of my explorations in Western Kansas.

PACHYRHIZODUS LATIMENTUM. Cope. sp. nov.

Represented by a right ramus mandibuli with the angle and cotylus deficient. The posterior portion of the dentary is also wanting, so that the number of teeth it supported is not ascertainable. The general form appears to have been deeper than in the *P. caninus*, while the size of the teeth is similar. The external face of the bone near the alveolar border is convex, and not particularly rugose. The external alveolar wall is well elevated above the inner. Below the latter, the dentary bone ex-

hibits a strong longitudinal ridge. The extremity of the dentary takes a wider curve from the symphysis than in *P. caninus*, giving a broader chin (whence the name) and muzzle. The symphysis is smooth transverse trilobate, the two outer lobes being separated by an emargination in the position of the foramen mentale. This form is very different from that in *P. caninus* where the symphyseal surface is sub-round.

The anterior teeth are smaller than the median, and have the inner alveolar wall nearly as much elevated as the external. The crowns are scarcely distinguishable from those of the *P. caninus*, being curved conic, with round section and smooth cementum. They form a single incurved row next the symphysis. Number of teeth in an inch at middle of ramus, 4.5.

From a cañon near the Smoky River near to the *Icthyodectes anaides m.*

PACHYRHIZODUS SHEARERI. Cope. sp. nov.

Associated with the bones of the *P. caninus* is a slender bone of oval section, which is marked on one edge by twenty-two transverse alveoli whose outer margin are a little higher than the inner. No teeth preserved. It may belong to a fish of this genus, and is probably a superior maxillary bone. Constantly with this position its outer extremity is more compressed than the proximal, the thickening being especially seen in the superior margin. A shallow concavity passes obliquely across this border from within outwards and distally as in *P. caninus*, but the articular face is not preserved. There is a longitudinal angle on the external face, and the superficial layer of bone is nowhere grooved or rugose. The pleurodont character of the tooth attachment is more marked proximally. Length of piece, M. .041 ; vertical diameter, .007 ; greatest transverse do., .0033.

This species is dedicated to Doctor Shearer, Assistant Post Surgeon, to whose interest in the subject, the Geology of Kansas is indebted for many useful discoveries.

EMPO. Cope.

In this genus the character of the teeth is quite similar to that of the preceding group, but the arrangement on the maxillary bone is different.

The characters are :

Maxillary teeth anteriorly in two series, an external marginal of subequal teeth, and an inner and superior of probably small extent, but which terminates anteriorly in two large canine teeth.

Only one species is known to me.

EMPO NEPAHOLICA. Cope. sp. nov.

Established on a portion of the right maxillary bone of a single individual. It displays the anterior squamosal suture for the premaxillary, and not far posterior to this on the superior margin, a concavity for contact with palatine, pre-frontal or other bone as the case may be. The posterior portion is lost. The premaxillary sutural margin extends at right

angles to the alveolar edge to beyond the middle line of the side of the maxillary. Above this point a process of the latter extends above the premaxillary for half an inch; it has a broad inferior sutural face; its upper margin is thin and oblique. A short truncate process rises behind the superior cotyloid surface. The teeth are cylindric conic, slightly incurved; on a margin of .035 M. there are five teeth and five vacant alveoli. The teeth of the inner row are much smaller, and on .017 M., there are eight bases. The bases of the two large teeth occupy .014. Depth of maxillary at large teeth, .019; at fractured end, .014. The anterior teeth of the external series are not larger than those of the inner.

The precise locality of the Niobrara chalk where this species was found has been mislaid. There is a possibility of its belonging to the *Pachyrhizodus latimentum*, but the smaller relative size seems to contradict the supposition. Should it be verified, the latter species must be referred to the genus *Empo*.

STRATODONTIDÆ.

In this group I have arranged several genera which resemble *Enchodus*, the longest known of its forms. They are Physostomous fishes as indicated by the relations of bones of the superior arch of the mouth; the absence of spinous dorsal radii; the cycloid scales, and the general relationship to *Esox*. Agassiz and others have regarded some of them as allied to *Sphyræna*; this opinion was probably derived from the consideration of the forms of the teeth which to some degree resemble those of *Sphyrænidæ* and *Trichiuridæ*. This is, however, like many other minor characters, one of those which appear in both of the great groups of osseous fishes.

The premaxillary is small, and supports a large tooth in *Enchodus*; in *Stratodus* it is also short and supports numerous teeth. In *Stratodus* the maxillary supports a few teeth, in *Cimolichthys* a larger number. Relationship to *Esox* is displayed by *Stratodus*, which has broad flat palatine bones closely studded with teeth in a brush, and where the maxillary teeth are reduced in size and number. The teeth are attached by the anchylosis of the base to the alveolar face of the jaw, resembling thus existing fishes, and differing materially from the families of *Pachyrhizodontidæ* and *Saurodontidæ* already considered.

The genera known to me are the following:

Premaxillary with numerous small teeth, maxillary with a few of the same; palatines covered with brushes of similar teeth, all with pulp cavity..... *Stratodus.*

Premaxillary (?) Maxillary with a single series of large teeth which have one cutting edge at base and two at apex. Dentary with inner series of large teeth which do not enlarge distally, and some series of exterior smaller teeth..... *Cimolichthys.*

Premaxillary with a single large tooth; dentary with an outer row of small and an inner row of large teeth, which are much larger at the distal end..... *Enchodus.*

STRATODUS. Cope.

This genus is well characterized by its dentition, which is remarkable for the small size and large number of the teeth, and their peculiar form. I possess one premaxillary, a considerable part of the maxillary, and nearly the whole of both palatines, besides other bones of one species. These were found not very far from the remains of the *Cimolicthys semianceps m.* and it required some investigation to determine the relationship between them. I have, however, portions of the maxillary and premaxillary of *Cimolichthys*, and both of these elements are so very unlike those in *Stratodus*, that there can be no doubt of its independence. I have, unfortunately, no dentary bone of *Stratodus*, and the outer row of palatines resembles in some measure those figured in *Cimolichthys levesiensis*, Leidy, by Agassiz.

The *premaxillary teeth* are in two series. They are stout at the base and oval in section, and are contracted and flattened rapidly upwards. On this basis is set an oval sharp edged flat, or spade-shaped crown, the long axis of compression being placed at right angles to that of the compression of the apex of the base. This gives a barbed appearance. The *maxillary* teeth are similar in form, but are in but few rows. The *palatine* teeth are constructed on the same plan, but they are longer, and the bases are subcylindric and slightly curved. All the teeth possess a large pulp cavity.

The *premaxillary* bone displays some of the density of composition seen in *Enchodus*. Its upper anterior surface meets the inferior of an acute angle. It is a broad oval, and is slightly concave. The inner face forms a truncate rim round the bases of the inner teeth, and terminates in a vertical crest of dense bone. The external face is, on the other hand, perpendicular, and extends obliquely upwards and backwards. An acute anterior angle of the *maxillary* under-runs it below, so far as to exclude all but one or two of the premaxillary teeth from the outer row. The external lamina of the premaxillary forms an extensive squamosal suture with this part of the maxillary by overlapping it from above.

This arrangement shows a certain similarity to *Esox*, especially in the large number of palatine and small number of maxillary teeth. It differs materially in the lack of articular surfaces between the maxillary, palatine, etc., in the upward prolongation of the premaxillary, and the peculiar forms of the teeth.

STRATODUS APICALIS. Cope. sp. nov.

Established on one incomplete individual, as above mentioned.

The maxillary teeth are mostly smaller than the premaxillaries, and diminish in size posteriorly; there are four or five series of them anteriorly. Seven to nine rows on the palatine bones; they are slender and curved downwards from oblique bases, and cylindric in section; they contract to a neck and then expand into the ovate spade-shaped cutting apex. They are in every respect the largest of the teeth, some making

a half inch in length. Those on the inferior or outer margin are most slender; those of the inner stouter and more conic. All the spade-like apices are black in the specimen, while the shanks are pale, except the premaxillaries. The *palatine bones* are flattened in one plane, and contracted at both ends. At the anterior, there is an external concavity perhaps for maxillary or premaxillary. A ridge divides the upper surface lengthwise; the outer edge is thin posteriorly, and there are two long grooves which extend to the posterior extremity, probably for sutural union with the pterygoid. The *premaxillary* bears a slight resemblance to the mandibular bone of a Chimæroid turned upside down.

	M.
Length portion of an *os palatinum*	0.128
Do. restored	148
Greatest width	.02
" thickness on margin	.003
Length premaxillary, fragment	.043
" " inner side	.025
" " outer to maxillary	.012
Width " in front above	.01
Length premaxillary tooth	.005

This fish was considerably larger than *Esox reticulatus* or *E. lucius*. In the lack of mandible its habits cannot be fully inferred, but the armature of the superior bones of the mouth is less powerful relatively than in those fishes.

Found by myself in the blue limestone shale on Butte Creek, south of Fort Wallace, Kansas.

CIMOLICHTHYS. Leidy.

Proceed. Acad. Nat. Sci. Phila., 1856, p. 202. Trans. Amer. Philosoph. Soc., 1856, p. 95. *Saurodon*, Agassiz, pt. Poiss. Foss.

In this genus the principal teeth are stout, and have a compressed apex with a prominent anterior cutting edge, and a less extended posterior one. There are several series of smaller teeth external to the large ones in the lower jaw, while in a portion of an upper jaw of one of the species these are wanting. Where present, they are more acute than the larger ones. The large teeth diminish gradually in length to the symphysis, a circumstance which separates these fishes from *Enchodus*, where one or more of the anterior teeth are elongate. In the species here described, the bases of the teeth are enlarged and deprived of cementum coat, but there are no true roots.

The maxillary bone terminates in a narrowed extremity with obtuse termination as in *Stratodus*. The vomer in one of the species is acuminate at one end, and supports a short series of teeth, the middle portion in a double row. All the teeth are without pulp-cavity.

The only indication of the mode of succession of the teeth is furnished by the specimen of *C. anceps*. Here a small excavation appears on the

inner side of the basis of the tooth. The absorption commencing at this point no doubt removes the bases so that the crown falls away.

The name used was applied by Dr. Leidy to a fish erroneously referred by Agassiz and Dixon to *Saurodon*, Hays. He did not characterize it, and until the barbed palatine teeth characteristic of it are discovered in our species, their reference to it will not be fully established. In the parts preserved they appear to be identical.

The general affinities of the genus will receive new light from materials now in my possession and not yet developed.

The *Sphryiæna carinata*, Cope (Hayden's Rept. Wyoming, etc., p. 424), probably belongs to *Cimolichthys*.

CIMOLICHTHYS SULCATUS. Cope. sp. nov.

Indicated by a left dentary bone with attached parts of angular, etc. The fragment supports thirteen teeth at equal distances, the intervals often presenting traces of tooth bases. The bases of the teeth are round and the crowns become compressed to the tip. They are strongly curved backwards and acute. The anterior margin is particularly convex and acute, forming a cutting edge, but there is no edge on the posterior face. The surface is rather finely striate-grooved on the inner and posterior faces. The teeth of the exterior series are in several rows, that next the large teeth being considerably larger than the others. They are curved inwards and are flattened, having cutting edges on both anterior and posterior margins. Cementum smooth. The external smaller teeth are shorter in relation to their length, not curved, and two-edged.

The dentary bone contracts irregularly to the symphysis, and has a thickened inferior margin. The symphyseal surface is small, and presents a marked fossa. The external face of the bone is divided by a deep longitudinal groove which is overhung by the produced extremity, and which gives exit to the mental foramen. The external face of the dentary has an impressed groove along its lower third anteriorly, and its surface is sculptured with deep longitudinal sulci, which often run together.

	M.
Length of fragment	0.18
Depth of first tooth	.01
" seventh "	.028
" tenth "	.045
Total elevation of fifth tooth	.014

The restored cranium of this fish is about one foot in length.

From near the Smoky River in Western Kansas.

CIMOLICHTHYS SEMIANCEPS. Cope. sp. nov.

Established on remains of two individuals. One of these embraces vertebræ, portions of vomer, maxillary, mandibular and other bones with some scales. The other consists of a dentary bone with symphysis and teeth.

These indicate smaller individuals than that typical of *C. sulcatus*, but the principal difference is to be seen in the teeth. These are rather more elongate, and they have a cutting edge on the posterior aspect of the apex as well as on the anterior. It extends but a short distance while the anterior rises near the base, and is strongly convex. The tooth curves backwards; the base is round in section. The convex posterior and the inner faces are rather finely striate-grooved. The larger teeth of the external series are convex on the inner face; they are two-edged, and slightly incurved.

The outer face of the *dentary* bones is strongly longitudinally parallel sulcate. The inner face and the surfaces of all the other bones are minutely striate exactly as in some of the *Mosasauroids*, *Clidastes propython*, for example. The anterior extremity of the *maxillary* is straight on one side, and obliquely beveled on the other to an obtuse compressed apex. The bevel becomes sub-horizontal posteriorly, indicating a rather shallow bone. Two of its anterior teeth are a little larger than those that follow. The supposed *vomer* is narrowed to a beak posteriorly (?), and presents an elevated longitudinal and obtuse ridge on the middle line. This supports a row of nine teeth, five of them having mates. The bone expands at the other end for a squamosal articulation with other elements. The vomerine teeth are smaller than the larger dentaries.

The *vertebræ* are elongate and much contracted medially; the rims of the cups are thickened, and the cups themselves very deep. There is a trace of a single median longitudinal groove. The neural and hæmal arches are represented by broad longitudinal laminæ in the specimens. The vertebræ are thus very different from those of the *Saurodontidæ*, and bear more resemblance to those of *Cyprinodontidæ*.

In the *ramus* with symphysis, the characters of the latter resemble those in *C. sulcatus*. It is very small, and does not exhibit the fossa of the latter species. The mental foramen does not continue as a groove to the edge, while there is a deep groove on the inner face opposite to it, not seen in *C. sulcatus*.

The first described specimen would have been, perhaps, a twenty-five pound fish in life. Both specimens were from near Butte Creek, at some distance apart.

CIMOLICHTHYS ANCEPS. Cope. sp. nov.

Established on portions of a right maxillary bone of one individual, and, perhaps, the premaxillary of a second. The former supports six teeth and four empty alveoli.

In accordance with characters derived from study of *C. semianceps*, there is no external series of smaller teeth on the maxillary. The maxillary has a flattened anterior extermination, somewhat as in *Stratodus apicalis*, the superior face being excavated and widened and gradually descending to meet the inferior. The line of junction, where also the premaxillary commences, is oblique from before inwards, and backwards. The anterior tooth is a little larger than those following. The form of

the teeth differs much from that seen in the species just described. They have an oval section at base, but speedily become much compressed in a direction oblique to the long diameter of the bone, and develop cutting edges opposite to each other, and separating equal faces. The crown is a little more convex on one edge than on the other, and has a slight inward curvature. The apex is sharp. The cementum of the crown is smooth, but the surface of the basal portion below the commencement of the cutting edges is minutely striate-grooved, some grooves being deeper than others, the surface having a silky lustre.

The surface of the bone where preserved is without special sculpture. The upper margin is grooved for articulation with a supernumerary maxillary.

	M.
Teeth in M. .01, two	
Length of last maxillary tooth	0.008
Long diameter of basis of "	.004
Depth maxillary bone at "	.012

The premaxillary bone belonged probably to a smaller fish. It has the characters seen in *Enchodus* but is shorter and deeper than in the known species. The lateral groove is here subvertical and on the anterior face extending to near the basis of the tooth. The inferior face behind the tooth expands gradually to its base, which is marked by the narrow crescentic scar of the older tooth seen in *E. pressidens*. The crown of the tooth was scarcely as large as that of the maxillaries, but is lost. Its basis is fluted, and the surface finely striate. Length of bone, M. .015. This specimen was not found with the preceding. The latter was discovered on the same bluff that produced the *C. semianceps* and the *Stratodus apicalis*, at some distance from them.

CIMOLICHTHYS GLADIOLUS. Cope. sp. nov.

Represented by a single elongate tooth which is intermediate in character between those of the two species last described, but much larger than either. It is too large for an anterior maxillary tooth of *C. anceps* and should it pertain to the end of the mandibular series, will in so far resemble the genus *Enchodus*. But the cutting edges are opposite to each other, and not, as is usual in that genus, on one side, leaving the inner face very convex. In this species the crown is rather slender and compressed above the base. The anterior cutting edge extends to the bottom, while the posterior reaches only half-way down; there is no barb. The section of the base exhibits an angle in continuation of the latter. The inner face is a little more convex than the outer; its posterior half is rather coarsely striate keeled. The posterior half of the outer face is finely striate. The inner posterior aspect of the root presents a cavity of absorption for the successional tooth, as in *C. anceps*. The cutting edge and top of apex are glossy black. Length from fossa, M. .019; diameter at do., .006.

From a locality at a short distance from that of *C. anceps*.

ENCHODUS. Cuvier.

Remains of species of this genus occur in the cretaceous strata of Kansas. I discovered a tooth belonging to one of them, in the matrix beneath the vertebræ of *Elasmosaurus platyurus*. Dr. Leidy describes a species* from the cretaceous formations of the Upper Missouri region, which he called *E. shumardii*. The premaxillary of a rather large species was obtained by my expedition, but the species is not determinable. The diameter of the basis of the tooth is M. .012. The long tooth of a species of medium size was detected, as follows:

ENCHODUS CALLIODON. Cope. sp. nov.

Enchodus sp. Cope. Hayden's Surv., Wyoming, etc., p. 424.

The tooth on which this species rests is especially elegant. It is quite slender, and gradually contracts to the acute apex. The cutting edges, which extend to the base, are on one side, and are separated in one direction by a narrow, slightly convex, and perfectly smooth face. The inner face is strongly convex, being more than half a circle from the middle of the length downwards. This is also smooth on its anterior and posterior aspects, but on the inner, there are nine sharp delicate keels which disappear as the tooth contracts, the last terminating with the third quarter of the length. Total length, M. .02; longitudinal diameter at base, .0025; transverse do., .0035. The apex of the tooth is black.

From near Fossil Spring, Western Kansas.

(?)———————

ANOGMIUS. Cope.

(Proceed. Amer. Philos. Soc., 1871, p. 170.)

This name was applied to a genus supposed to be allied to the *Saurodontidæ*, and represented by vertebræ only. One species was named *A. contractus*, Cope, l. c., which was found by Professor Mudge. I have seen nothing resembling these vertebræ among either of the three families above described, and cannot ascertain their exact affinities without further investigation. It is clear that they are not referable to the known genera of *Saurodontidæ* nor of *Stratodontidæ*. They present a marked character in the crowding together of those caudal vertebræ which precede those that support the caudal fin. The centra are shortened and the prolonged neural and hæmal arches and spines lie one on the other, forming a fan-shaped body. The arches do not, at the same time, become anchylosed. This structure is seen in the *A. contractus* and in a second and smaller species. It finds a parallel in the caudal vertebræ of the genus *Ischyrhiza* of Leidy from the green sand of the New Jersey cretaceous, where all the elements of this fan-shaped body, centra, spines, etc., are coössified into a solid mass. This will define family. A species having the same structure is common in the Miocene of Maryland. In

* *Enchodus shumardii*, Leidy, Proc. Ac. Nat. Sci., Phil., 1856, p. 257. is a smaller species than any of the Cimolichthyes here described.

Anogmius, the sides of the centra, though lacking the grooves of other genera, are striate-grooved and reticulate. So are those of *Ischyrhiza*, and both in this resemble the recent genus *Esox*. Add to this the fact that the teeth of *Ischyrhiza* are almost exactly like those of *Esox*, especially as to their large fissured fangs, and half-pleurodont insertion, some relationship to the *Esocidæ* may be predicated. This is the first hint I know of as to the affinities of *Ischyrhiza*.

Anogmius contractus was about the size of *Ichthyodectes prognathus;* the second *Anogmius* is not more than one-third the size, the caudal vertebræ are more aggregated, and the neural spines after leaning backwards are turned upwards. The specimen came from Lower Butte Creek; no parts of cranium or fins were found. The vertebræ originally described by me as pertaining to *Ichthyodectes ctenodon* belong either here or to *Ischyrhiza;* they agree with the latter in most respects, having the neuropophyses coössified with the centrum. They are several times larger than those of *A. contractus* and relatively shorter, being about equal to those of *Ischyrhiza mira*, Leidy.

I do not name these species, as they may be *Pachyrhizodontidæ*, and will be in any case better identified from cranial and fin remains.

SELACHII.

Remains of sharks and rays are far less abundant in the cretaceous of Western Kansas than in New Jersey, and are much exceeded in abundance by the Physostomus *Actinopteri*, as the present account indicates. In the region near Fort Hays and Salina, sharks' teeth are more frequently found. Those from near Fort Wallace belong to but two species of the genus.

GALEOCERDO. Müll. Henl.

Galeocerdo crassidens. Cope. sp. nov.

Established on two teeth of the type of *G. aduncus*, Agass., *i. e.*, with one cutting edge much more convex than the other. The processes of the fang are rather narrow, that beneath the convex cutting edge the most so. The apex of the tooth is very short, entirely plane, and stands over the middle or inner edge of the wider process of the fang. The shorter cutting edge is straight or convex to near the base, where a short divergent keel develops itself. The anterior edge is strongly convex, and all the edges are denticulate. One side is more convex than the other. No denticles. Cementum smooth.

	M.
Length basis	0.014
Height crown	.01
" root	.005
Width tooth at contraction	.01

Galeocerdo hartwellii. Cope. sp. nov.

This species is of the *edgertonii* group, *i. e.*, with the cutting edges sub-equal and symmetrical. The basis is broad and with convexities of

the fang instead of the processes of the last species. The external parts of the cutting edge rise slowly from the base, and then rise more steeply at an obtuse angle. They are convex on each side above, and meet symmetrically, forming a little less than a right angle. No denticles; cementum smooth. Edge everywhere denticulate. One side of crown plane, the other convex.

	M.
Length basis	0.0115
" fang	.0495
Elevation of apex (from concavity)	.0145
Width crown at contraction	.042

This tooth is stouter and larger than that of *G. edgertonii*, and was found beneath the bones of the *Protostega gigas*. It is named after Martin V. Hartwell, a member of my expedition, to whose acuteness and industry I owe many specimens.

GENERAL OBSERVATIONS.

The following species have now been described from the cretaceous formation of Kansas:

SAURODONTIDÆ.

Portheus molossus. Cope.
Portheus thaumas. Cope.
Ichthyodectes anaides. Cope.
Ichthyodectes ctenodon. Cope.
Ichthyodectes hamatus. Cope.
Ichthyodectes prognathus. Cope.
Ichthyodectes multidentatus. Cope.
(?) *Xiphactinus audax*. Leidy.
Saurocephalus phlebotomus. Cope.
Saurocephalus arapahovius. Cope.

PACHYRHIZODONTIDÆ.

Pachyrhizodus caninus. Cope.
Pachyrhizodus kingii. Cope.
Pachyrhizodus latimentum. Cope.
Pachyrhizodus sheareri. Cope.
Empo nepahollica. Cope.

STRATODONTIDÆ.

Stratodus apicalis. Cope.
Cimolichthys sulcatus. Cope.
Cimolichthys semianceps. Cope.
Cimolichthys anceps. Cope.
Cimolichthys gladiolus, Cope.
Cimolichthys (?) *carinatus*. Cope.
Enchodus calliodon. Cope.

FAM (?)

(*Apsopelix sauriformis*. Cope. Hayden's Report, Wyoming, 1871, p. 423.)

SELACHII.

Galeocerdo crassidens. Cope.
Galeocerdo hartvellii. Cope.

Of the preceding twenty-four species, the greater part are Physostomous *Actinopteri*, and there is no species of a Physoclystous family in the list.* No trace of spines or scales of fishes of the latter character have been yet discovered in strata of this period in the West, though one (*Beryx insculptus*, Cope,) has been discovered by Dr. Lockwood in the green-sand marl of New Jersey.

In the second place, it is of importance to observe that the genera have nearly all been obtained from the chalk of Europe. *Portheus* is represented perhaps by some specimens referred to *Hypsodon*; one species of *Ichthyodectes* is figured by Dixon from Sussex, and one of *Cimolichthys* and *Pachyrhizodus* each. *Enchodus* has long been known from Holland, etc., *Apsopelix*, *Empo* and *Stratodus* being so far the only ones not found in Europe. This is of much interest in every respect, and points to the synchronism as generally understood, between the chalk formations of Kansas and of England.

Stated Meeting, February 16, 1872.

Present, 16 members.

President, Dr. WOOD, in the Chair.

A carte de visite photograph and letter, acknowledging receipt of diploma of membership was received from Prof. Charles H. Hitchcock, dated Hanover, N. H., February 3d, 1872.

A photograph was received from Rev. E. R. Beadle, dated 1824 Delancey Place, Phila., Feb. 7th, 1872.

Letters acknowledging the receipt of diplomas of membership were received from the Rev. E. E. Hale, dated Roxbury, Mass., Feb. 5, and from Mr. Edward Quincey, dated Dedham, Mass., Feb., 1872.

* In describing *Elasmosaurus* I state that remains of six species of Physoclystous fishes were found in the matrix surrounding the bones. This statement was founded on the assumption of previous authors, that the forms of fishes above described were related to *Sphyraena*.

A letter accepting election to membership was received from Prof. G. W. Hough, dated Dudley Observatory, Albany, Feb. 1, 1872, sending also a donation for the Library.

Letters acknowledging the receipt of the Publications of the Society were received from the I. Academy at Vienna, Jan'y 7, 1871 (XIII., iii. 81, 82); R. Society at Upsal, Nov. 1, 1870 (77, 78, 80, 81, 82); R. Library at the Hague, Aug. 27, 1870 (XIII., iii. 82); July 15, 1871 (XIV., i., iii. 84, 85); Holland Society at Harlem, June, 1871 (XIV., i., ii., 84, 85); Batavian Society at Rotterdam, Sept. 23, 1870 (XIII., iii., 82, 83); July 26, 1871 (XIV. i., ii., 84, 85); Royal Academy at Amsterdam, Dec. 15, 1869 (XIII. iii., 81, 82, 83); R. Academy at Brussels, Aug. 30, 1870 (82, 83); July 15, 1871 (XIV. ii., 84); Society of Physics, &c., at Geneva, Oct. 1, 1871 (XIV. i., ii., 84, 85).

Letters announcing the envoy of publications to this Society were received from the Im. Academy at Vienna, Sep. 26, 1871; R. Society at Upsal, Nov. 1, 1870; Observatory at Prag., Sep. 22, 1871; Geological Society at Dresden, Oct. 15, 1871; Central Scientific Bureau at Harlem, July 30, 1871; Batavian Society at Rotterdam, May, 1871; R. Academy at Amsterdam, Oct. 24, 1870; R. Academy at Brussels, July 25, 1871.

Donations for the Library were received from the Société Imp. des Naturalistes at Moscow, Royal Society and Observatory of the University at Upsal, Royal Prussian Academy, Verein für Erdkunde at Dresden, Natural History Society at Bamberg, K. K. Observatory at Prague, M. Barande, Holland Society at Harlem, Royal Academy at Amsterdam, Batavian Society at Rotterdam, Royal Academy and Observatory at Brussels, M. Quetelet, Physical Society at Geneva, Geological Committee of Italy, Signor Anianelli, of Naples, Geographical Society at Paris, Bureau des Longitudes, Revue Politique, M. Chabas of Châlons sur Sâone, the Essex Institute, Boston Public Library, Dudley Observatory, Mr. W. W. Mann, of New York, Medical News and Library, Half Yearly Abstract of Medical Sciences, Penn Monthly, U. S. Secretary of the Interior, and Prof. J. S. Newberry, of the Ohio Geolog. Survey.

The Committee on the observation of the next transit of Venus, made a report, with a memorial to Congress, to be signed by the officers of the Society, and another, of like import, to be signed by members of the Society, and others who may be disposed to join in the object proposed.—The report was accepted, and the Committee discharged, and the memorial directed to be signed by the officers of the Society.

A paper was read by Mr. P. E. Chase, on the Correlation of Cosmical and Molecular Forces, which was referred to a Committee, consisting of Profs. J. F. Frazer, E. O. Kendall and S. J. Gummere.

Prof. Cope laid upon the table certain fossil remains from Utah, and presented a paper descriptive of their geological positions and relations, entitled, "On Bathmodon, an extinct genus of Ungulates."

A memoir on the Geology of West Virginia, by J. J. Stevenson, was presented by J. F. Frazer, and referred to the Secretaries.

Pending nominations Nos. 689–691, and new nomination No. 692, were read, and the meeting was adjourned.

Stated Meeting, March 1, 1872.

Present, 18 members.

Vice-President, Prof. J. C. Cresson, in the Chair.

A letter was received from Mr. S. W. Roberts, accepting his appointment to prepare an obituary notice of Mr. E. Miller.

A letter of envoy was received from the R. Society of Antiquaries, London, Feb. 26, 1872 (XIV. iii. 87); Boston Public Library, Feb. 28, 1872 (XIV. iii.); N. York Hist. Soc. Feb. 26, 1872 (XIV. iii.); Mass. Hist. Soc., Feb. 26, 1872 (XIV. iii.).

Donations for the Library were received from the R. Belgian Academy, Revue Politique, London Nature, Royal Society, R. Astronomical, Chemical and Antiquarian Societies, and Society of Arts and Institutions in Union, H. M. Sec. of State for India, Greenwich Observatory, Geological and Polytechnic Society of West Riding of Yorkshire, Leeds Phil. and Lit. Soc., Belfast Flax Extension Association, New Bedford Public Library, Prof. C. H. Hitchcock, Boston Old and New, American Academy of Arts and Sciences, New York American Chemist, Philadelphia Journal of Pharmacy, Bureau of Secretary of War at Washington, and the University of Virginia.

The Committee to which was referred Prof. P. E. Chase's paper on the Correlation of Cosmical and Molecular Forces, reported in favor of its publication in the Transactions, which was so ordered.

Mr. Lyman presented, for the Transactions, a description of a part of the Coal region of Southern Virginia, with an accurately surveyed map of the same, which was referred to a Committee, consisting of Mr. Lesley, Prof. J. F. Frazer and Dr. Genth.

Prof. Cope read, by title for the Proceedings, two papers, entitled, "On two new Ornithosaurians from Kansas," and "On the genus Protostega, a form of Extinct Testudinata," which were referred to the Secretaries.

Mr. Price read the first portion of a Communication entitled, "Another Phase of Modern Philosophy."

Prof. Stevenson's paper, read at the last meeting, was, on motion of the Secretary, referred to a Committee, consisting of Dr. Genth, Mr. Lesley and Prof. Frazer, Jr., to report on the propriety of publishing it in the Transactions of the Society.

The Report of the Treasurer of the Trustees of the Building Fund was read by Mr. Marsh.

Pending nominations, Nos. 689 to 692 were read.

And the meeting was adjourned.

ANOTHER PHASE OF MODERN PHILOSOPHY.

By E. K. Price.

(*Read before the American Philosophical Society, March 1st*, 1872.)

"All flesh is not the same flesh." "There is one flesh of men and another of beasts." "What is a man profited if he shall * * * lose his own soul?"

Those who have lived through nearly three-fourths of the Nineteenth Century, and witnessed the many useful and brilliant discoveries that have illustrated the past two ages, may not safely venture to discourage the boldness of any investigations that are legitimately pursued. Nor will any one properly criticise or censure those who in the main are doing good service to science, unless he clearly perceives that the great canon of philosophizing, which all must acknowledge, has not been duly observed. When such case occurs in matters of highest importance, it then becomes the duty of the humblest to speak out in the correction of what he believes to be error, in the name of an all-pervading philosophy, and in behalf of our common humanity, according to his own conviction and ability.

The first lesson the scientist should learn is that of the limit of the human understanding, beyond which it is useless to attempt to investigate; and to recognize as inviolable those secrets which the Creator has chosen to reserve to Himself, and to which there is no response to interrogation. The second, is to make sure of all the facts requisite to the ascertainment of truth, and thence to draw only such conclusion as the known facts will justify.

The physicists of this century have studied life from its physical basis, and have too often made the life and the mind of man the product of matter. I propose to discuss this theory, particularly in review of Professor Huxley's Physical Basis of Life, both to show that he has drawn his conclusions upon inadequate facts, and that he has left out of view the facts that show the distinctive nature and operations of the life and of the mind.

Let us first consider a few of the subjects having a bearing upon his theory, wherein the limit to knowledge is recognizable, beyond which further research is sure to be baffled. Nothing is more familiar to us than our own life. It is that self we should best know; and we can and do know many things about it; indeed all about it, except the mystery how it can possibly be, and can carry on its own functions. We can see and dissect our bodily structure of bones, joints, muscles, tendons; brain, nerves, tissues; heart, arteries, veins, etc. We see and feel the body's functions as they are carried on. We see how it is fed with food, and how the circulations are kept going and the strength is maintained; and know that the food taken is transmuted into the living being. We are invited to eat and drink to appease hunger and thirst, and thereby we both avert greater pain, and enjoy pleasure. The food is dissolved by the gastric juice secreted by the stomach, and is then *chyme*. This in its de-

scent receives the juice of the *pancreas*, and the bile from the gall-bladder of the liver. The action of the stomach keeps its contents in motion; and one portion, unfitted to enter the life-process, is rejected into the draught; the other called *chyle*, is a milky fluid, which the *lacteals* opening into the intestines imbibe and carry to the thoracic duct and into the venous system. The heart propels the crimson blood that is returned to it by the veins, together with the contributions of chyle, upon the lungs, where it meets the oxygen of the air, is decarbonized, and becomes scarlet; and this bright red blood, being returned to the heart, is propelled through the arteries to the extremities of the body, freighted with all the material the system demands; the corpuscles for bone, muscle, tendon, tissue, etc., and delivers them as and where wanted, and from the extremities the blood is returned through the veins to the heart. The process of life is carried on by ceaseless pulsations. The heart throbs; the arteries expand and contract; the stomach, the diaphragm and chest expand and contract; the lungs are kept in play, and we breathe; the intestines are operated by the peristaltic motion, and the glands and absorbents are ever at work. All this we perceive, or the anatomist or physiologist does for us, and to him all is as familiar as things of daily observation. But can he tell us what life is, or how it acts with an intelligence surpassingly wonderful? We see in this process that the food has become part of the living being; and it will remain such so long as it is useful to the creature, and when any part becomes useless in the animal economy it is rejected, so that after a few years the whole system is composed of new materials, but the same life of identical consciousness has survived, and may survive more than ten entire changes of the life-molecules. It is the life in the body, and only the life that has had power to take in, digest, and assimilate the organic food we eat, and make it part of itself. Why or how the thing we call life can do all this, no microscope reveals to our sight; no skill of dissection can reach it; no cunning of thought can teach us. We only witness the process and the fact of life. The Power that created the life, and endowed it with its wonderful intelligence, has chosen to keep this secret to Himself; and though it is ourself, and we are always conscious of its presence and action while we live, we can never tell what it is, or how it lives. We must accept it as an ultimate fact; but from that fact we may, if we are logical, infer that it had an Author, who could create it, and yet permit us never to know His secret, though that secret be our own life. The unknowable is thus dwelt upon not only to heighten our conception of Deity, but to show where time and labor would be spent in vain; and also, because it is salutary that all who investigate science should do so with the humbling consciousness that all that is known bears a very small proportion to that which here cannot be known. Yet, from the known, from the evidence of its design, and power, and beneficence; its obedience to law, and harmonious movements; its grandeur and glory, we surely infer a Creator, Almighty and Omniscient.

Let us go back a stage in the being of this life, whose source and nature we are invited by Dr. Huxley to investigate. From a vitalized ovum, seemingly but a speck of jelly, the fœtal being is developed into a body, with every part prepared to begin the hardening process of breathing life. Until birth it derives its nourishment from the mother by the umbilical cord attached to its navel. In due time it is expelled, by nature's timely effort, that child and mother may continue to live. The physical ligament that united them is severed, and the separate life begins. The child now breathes for itself, and takes food into its own stomach. Still the nourishment comes from the mother, and nature has provided it, as wanted, in her breast. At those fountains the child drinks by a process its instinct has already taught it. Its food is that adapted to enter into its circulation and nourish its life. The lacteal ducts absorb the milk and carry it into the current of life. Why this should all be, we readily understand; but how this harmonious process takes place, with such sure observance and beneficent end, we cannot penetrate. We say that nature and instinct do that we so admiringly behold. But if nature had an Author, then it was God who does it, to continue our race. Yet He retains the secret He chooses not to reveal.

But we must recede yet further to reach the physical beginning of life. In animals and vegetables of highest organization, we find that there are two sexes requisite to the reproduction of life. We will take the illustration from the vegetable kingdom, whence the inference may be made to the animal, including man. When the sun's warmth revisits us, and spring has come with her showers, we have also the flowers. These are not only for our pleasure and refinement of taste, but they are nature's bridal habiliments. The two sexes may be found in the same blossom; or in separate blossoms on the same, or different trees. The base of the pistils contains the female ovules, made but to perish in sterility unless they shall receive the pollen formed in the anthers of the stamens; but are not permitted to perish, for the breezes are ever transporting the dust of the pollen to the awaiting ovules; and the busy bee and insects, as they flit from flower to flower, assist in nature's requirement. In the speck of male dust is the beginning of life, to find its necessary receptacle in the female molecule of matter. The ovules are fructified; the flower fades and dies, for it has fulfilled its office; but the seed grows and matures, and is the germ of another life, that shall be like unto the parent. All this is watched, and surely observed; it is beautiful to behold, and of most beneficent purpose, for without it all vegetable and animal life would cease upon the earth. But the ultimate secret who can find out? Why the pollen should be requisite to fructification; how it should have the power thus to impart life, man has never found out, and probably will never discover. We have looked upon the renewed vernal life of the vegetable kingdom with sympathy, and in that sympathy we have invested nature with our own feelings, and she has seemed to us sensient of joy. And now, returning to ourselves, as subjects of the like process, we behold

the fruit to be not only new life, but in its consequences to be man's chief resource for all his happiness; for hence spring, the comforts and refinements that belong to the family; the love of wife and children; intellectual culture, developed affections; and the training of human souls. We have been thus led by a pleasurable instinct, and a virtuous obedience, to continue our race, and have found therein our best welfare and highest excellence. God has done this, yet has kept His secret.

But science will ever interrogate nature; does so boldly but not blamably. She will with telescope ceaselessly sweep the heavens; she will with microscope untiringly explore a boundless life that everywhere teems unseen by the naked eye; she ever applies her chemical tests and analyses as keen as the sharpened human intellect. Her researches are well rewarded; but she may not know all. For often it happens, that "Seeing ye shall see, and shall not perceive." With the microscope and scalpel the sources of life are explored, and science announces that all life, in the higher organizations, comes and is maintained by the blood propelled from the heart. Thence came the parental germs that have met and started the embryonic life; thence has come every increment that has given the body growth from the gelatinous germ to the mature man. You have traced the physical being back to nearly its starting point, and found its component parts all to have been molecules of matter, or corpuscles, or cells in the blood. These the physiologist declares to be the physical basis of life. We may not venture to deny this conclusion, for his dissections and magnified sight have revealed what he describes, and it comports with our observations. But chemical tests can but imperfectly verify his observations, for they can only be applied to matter dead, and when life has ceased to resist nature's chemistry, that chemistry is quick to change the material which had been the living source of life's supply. The assisted eye has seen in that crimson current, says Huxley, "innumerable multitudes of little, circular, discoidal bodies, or corpuscles, which float in it and give it its color, (and) a comparatively small number of colorless corpuscles, of somewhat larger size and very irregular shape." Huxley speaks of these as marvelously active, changing their form with great rapidity, as if independent organisms; and their substance he calls *protoplasm*. These he calls the units of the human body, and says: "Beast and fowl, reptile and fish, mollusk, worm and polyp, are all composed of structural units of the same character, namely, masses of protoplasm with a nucleus." "Thus it becomes clear that all living powers are cognate, and that all living forms are fundamentally of one character." Thus while Darwin would make all living beings related by descent from a common parent, Huxley would make all to be related as creatures of the same blood.

Now the only reliable basis for such conclusions seems to be the magnified vision, limitedly applied, revealing similarity of looks and activities. The elements of the universal protoplasm are stated to be "carbon, hydrogen, oxygen and nitrogen." But it is not shown or said that these

exist in the like proportion in the protoplasm of different creatures, which might explain much of the difference there is in their structure. Thus if the proportion of oxygen in the air was considerably increased, all life would be burnt up; and if the proportion of nitrogen were considerably increased in the atmosphere we breathe, all life would be extinguished. Without much more observation than appears to have been made, science cannot insist upon the sweeping generalization Dr. Huxley has made, that all living creatures are cognate. His facts are few, and the theory deduced runs counter to the common observations of men. Likeness in the looks of the white corpuscles, without showing of what they consist, or actually do, is not proof adequate to the induction. The ova in the ovarium of living creatures, and the initiate particle that vitalizes them, may appear much alike under the microscope; but from the ovum of one comes a fish, from another a fowl, from another a beast, and from another man. It is inferable that from the germ upwards the structures of these creatures have had various elements and in differing proportions. Were it not so, creatures so diverse in form and nature, it seems not reasonable to believe, could be the result. This objection Huxley does not attempt to explain.

Again, the different kinds of food that animals live upon show that the nourishment that feeds their life, in its first vitalized stage, called by Huxley protoplasm, must vary in the nature and proportions of its elements. Some live on animal food only; others upon grasses and grain only; man upon animal food, grain and vegetables. Some can eat with impunity things poisonous to others. Some, too, secrete deadly poison from the material within them. The qualities of the things eaten or drank must enter into the circulation and growth, and these must furnish molecules or cells of qualities such as the body demands. Portions of food are to be rejected; first without entering the circulation, and afterwards through the secreting glands. The breath of the drunkard shows that alcohol has entered his circulation and is exhaled from his lungs; it is shown in the capillaries of his face; and by dissection, it is perceived in the brain. The nursing mother, who has taken medicine, transmits a portion of it to her child, by the milk secreted from her blood. Many medicines are administered with the view to their effect through the blood-circulation. These enter the vital current and produce their known effects.

The cold-blooded and warm-blooded animals, the edible and poisonous, cannot be taken to be creatures of the same substance; and though they may have been built up from a fluid circulation, it cannot reasonably be inferred that they have been composed of the same elements; and if not of the same elements, the protoplastic theory to unify life becomes baseless: "All flesh is not the same flesh."

But if the vitalized ova and protoplasm that start and build up life were homogeneous, or approximately so, only the more wonderful must be the power of the life which can construct creatures of the diversity we behold in sea, or air, or upon the land, from the same elements. From

countless globules the work is done. But each living creature is to reproduce its like, and is ever to reproduce only that; such is its mission, and it unerringly fulfills that mission. Either the life does this, or He that created the life. It is no known property of matter to produce life. And the more the elementary materials are alike, the more each life must do; the more it must rule over the materials to produce the diversified results; and the less the materials could have had mastery over them. We know well what the life appears to do, for she does all under our eyes and within us; yet she dwells herself in impenetrable mystery. What she is, and how she can carry on her operations, no man may fully know. The keenest in scrutiny are not agreed as to the import of what they see, and Dr. Huxley has not explained whence the colorless corpuscles he calls protoplasm are derived; does not say whether they are particles of food or chyle in transition to blood corpuscles, as that which is more vitalized, or whether they are derived from the latter; or whether red blood contributes any material for the construction of the body. The proportion of the colorless corpuscles to the red is less than three in one thousand (Dr. Carpenter's Physiology, sec. 15). To make the few colorless corpuscles suffice for the consummation witnessed, seems cause inadequate to the results; and is to make the vastly greater mass of red blood useless in the process, except it be merely as a tide to bear along the vital corpuscles to the places of destined use. He gives no reason why the white should be the exclusive material; or as he compares it, why the clay or brick, with which the house is to be built, is alone to be used, though that house is to contain also all other requisites to comfort: the plastering, doors, windows, floors, furniture and upholstery. It appears to be an assumption requiring proof, that the few white particles alone contribute to form and repair the different parts, the bone, muscle, tendon, tissue, etc., and contrary to different ends to be subserved, and to the universal economy of nature that does nothing uselessly. These different parts demand particles of like nature to each respectively. We know, too, that the flesh may be changed in color and quality by the material fed, as the feeders of stock well know; and this seems proof that the elements that nourish and fatten are not protoplastically the same in substance or color.

Dr. Carpenter speaks of the red corpuscles as "especially concerned in preparing *pabulum* for the nervous and muscular tissues, the former of which is distinguished by the presence of phosphorized fats, and the latter by the remarkable predominance of the potash salts; and this view derives further confirmation from the fact that a flesh diet seems to have a decided effect in the formation of red corpuscles." (Physiology, Sec. 160.) And he devotes some paragraphs to show that the colorless corpuscles are but another stage of the evolution of the red corpuscles. (Sec. 163, etc.) Again he says, "That the corpuscles, however, both red and colorless, are living cells, and that, like other cells, they possess vital endowments peculiar to themselves, is not now questioned by any one." (Ib. Sec. 196.)

We are to go deeper than a certain likeness in protoplasms, to understand so much of life as we are permitted to know. Dr. Huxley in his article entitled, "Yeast," disclaims having said anything new in his lecture upon "The Physical Basis of Life." He is, however, responsible for what he adopts, and for the breadth and length of his deductions. Protoplasm he considers the basis of life, and that it is a physical basis; and he assigns no other than this as cause of life, and makes the life but a property of the protoplasm. He says: "If the properties of water may be properly said to result from the nature and disposition of its component molecules, I can find no intelligible ground for refusing to say that the properties of protoplasm result from the nature and disposition of its molecules." Nature is deemed exuberant of one aliment, called protoplasm, that supports all the life of the world, whether received by the roots into the circulation of the trees, or by the stomach into the circulations of animals; "a unity of power or faculty; a unit of form, and a unit of *substantial composition;* does pervade the whole living world." He continues, "All the multifarious and complicated activities of man are comprehensible under three categories: either they are immediately directed towards the maintenance and development of the body, or they effect transitory changes in the relative positions of parts of the body, or they tend towards the continuance of the species. Even these manifestations of intellect, of feeling and of will, which we rightly name the higher faculties, are not excluded from the classification." "This protoplasm exhibits the phenomena of life." These extracts, and the drift of the lecture show that the author is not merely showing what is the physical basis of life, but is attempting to show that life is but a property of matter which accounts for all bodily and mental activities. He makes life a property of protoplasm; and protoplasm a thing composed of carbon, hydrogen, oxygen and nitrogen; as water is a thing composed of hydrogen and oxygen; and that as "aquosity" cannot be said to exist to produce the water from said two gases, so is "vitality" not to continue to be spoken of as something existing in the living matter, which had no representative in the non-living matter which gave rise to it. But the water is a chemical compound, and protoplasm consists of parts not chemically united; but united by that thing called life that resists chemical action; that has properties of a nature other than chemical, and is in all nature peculiar and discriminated. We see that he would thus sink the life into protoplasm, and make it and the intellect but a property of matter. But others should make better observation and induction.

It may well be asserted from all that we can observe and know, that matter cannot originate life; nor life matter. Each logically demands a Creator. Life cannot originate itself; but only continue the previously created life, by a power conferred on life to continue life. Dead matter may be vitalized and thus become part of the living body; but the life must first be, to appropriate matter for its uses, to vitalize it, and to build up the living body and to continue it in life. In all time, only life has

initiated the beings of the successive generations. We have only to consider all we know to be assured of these truths. No protoplasm could now exist, unless life had produced it. It never has been chemically or otherwise than by life produced, except as first created. It is only found in the vital current produced from dead food. The immediate cause of it there must, therefore, be the preceding vital processes, endued with power to impart life to dead matter. In this result, Dr. Carpenter considers the liver and spleen perform important service.

The interest of science and truth require that we here take a yet closer view of life's origin and perpetuation. Our love of truth and our reverence for God will preserve us from every unhallowed thought. No observation or philosophy can account for the first pair of each living species, otherwise than by the logic that all that we behold must have had a transcending Creator. Our race must have had its Adam and Eve, or first parents, ungenerated. Judging from all that observation, and science, and history can teach us, every subsequent being has had its incipient germ of life from a male parent, but only to become another life when that germ has met the prepared ovule in the mother that is to afford the offspring its nourishment and growth. It is only that seminal germ that is the incipient life, that first unites with the ovules and afterwards appropriates every other particle of matter that enters into the life of the new being. How nourished from the mother, we have noticed. In due time, but by coarser food, the man and the woman of each generation are built up to their mature perfection. But it was the life, beginning as a speck, that began and has completed the structure by employing the subservient molecular matter. The matter of itself could have taken no step in the process; it could have sent not a cell to form the growing, living structure, if the pre-existing life had not prepared that cell from matter drawn by the life-process into the life-current, and afterwards placed it where the life-builder required its service. That which was dead in the stomach took life in the blood; for the life-blood had power to impart its life to the elements it needed for the body's growth. It is true now as when Moses gave his commandments, "The blood is the life; and thou mayest not eat the life with the flesh."

Dr. Carpenter says: "After the Chyle and Lymph have began to flow into the circulating current, the *continued* generation of red corpuscles is due to the progressive metamorphosis of the corpuscles of those fluids, is an opinion that has come to be very generally received by physiologists." (Ib. Sec. 168.) "Looking, again, to the undoubted vitality of the corpuscles, and to the strong ground for regarding fibrin also as an instrument of vital force, we cannot but perceive that the life of the blood is as legitimate a phrase, and ought to carry as much meaning in it, as the life of a muscle." (Ib. Sec. 221.) "Thus then, we seem justified in the belief that the Blood, like the solid tissues, has a formative power of its own, which it exerts in the appropriation of the new material supplied to it from the food." (Ib. 222.) "There is not, in fact, a more

remarkable indication of 'the Life of the Blood,' than is afforded by its extraordinary power of self-recovery, after having undergone the excessive perversion which is consequent upon the introduction of the more potent zymotic poisons; and every philosophical physician is ready to admit that, in this *vis medicatrix naturæ*, rather than any remedial agency which it is in his power to apply, he must look for the restoration of his patient." (Ib. Sec. 232.) It is the Life that is thus potent to carry on her work; to repel injury, and to cure.

Let any one look back upon the origin of life and its perpetuation, and he must say, in the retrospect, "Between me and the first man of my race the thread of life has never been broken. I am more than link of a chain; I am part of that first life, never yet severed. As his was from God, so is mine that of an ancestry of *one continuous life*." At the inception of each generation that has preceded each of us through many thousands of years, life was but an inherited speck; but that speck was part of the next preceding life—commissioned to seize upon matter for its growth, in manner to fulfill the design of the Creator of the first life, and no other—and bound to arrest its own growth when that design should be filled out; but yet continue the nurture of the normal being until its strength should be spent by its assigned lapse of years, or sooner termination by disease, or casualty. If it has left offspring, the continuous line of life may never be broken,—as certainly it will not have been as to any survivors of the race, whoever they may be; for between them and the first parent, at any future age, their genealogy, their life, will never have been severed. But the elements of matter that have composed the bodies of the countless ancestry will have been dissipated ten thousand times, and gone the many repeated rounds of life and death; yet one continuous line of life has connected all the generations by a continuity more complete than a chain of many severed but interlocked links—by an actual physical and vital portion transmitted from every parent to every child; being as truly one continuous life, as that the planted willow slip continues the life of the parent tree.

Let not, then, the materialist persuade us that matter has done all this by matter's inherent power. The ceaseless life has done it, compelling inert matter to obey it; and thus will it use matter to carry on all the life of earth, while the world shall last. The dead matter so used could of itself exert no such power; could not initiate life; could exercise no cunning of construction; but only life can continue, carry on, and perpetuate life; so transmute dead matter to living, and make it part of that life, whose stream in humanity commenced with the first created man, and will only end with the last. All this is sure induction from boundlessly observed facts; *and reverses the theory of the materialist.* And all that life has done so wonderfully and so intelligently, it has done and ever does without a conscious will of its own. It must, therefore, do it by a will and Power that is above it, and that rules the life; the Power that gives and rules the instinct of the animal; the Power that gives the

mind of man and also rules it, except as He has conferred upon it free-will, within permitted limits.

The author of the essay on the Physical Basis of Life, carries his induction beyond animate life. He makes matter cause of life, and he places vegetable life on the same basis with the animal, and makes the like protoplasm the source of both. Both, indeed, have their circulations in which are contained material elements for growth, but elements of a quite different nature and derivation. The animal lives on organic matter; dead matter that has had life in it; the vegetable derives its supply fresh from inorganic matter in the earth or air. This leaves us justly to infer that the elements of growth are of different kinds; and if so, that there then can be no protoplasmic kindred, and nothing is gained by the theory. The fluid in the thistle and other plants have a contractility that gives movement to the circulation and diffuses the molecules or protoplasm. That shows a different impelling force from that of the heart of the animal; and rather indicates a want of identity of protoplasmic material, while the wants of the two growths demand different material. The animal's circulation constantly repeats its rounds, while the plant's growth depends upon a single fluid transmission from root to leaf, and from leaf to root, as the seasons change. Huxley would confound the two great kingdoms of nature, because there is a very limited agreement in the appearances and behavior of the fluid supply of both. Contrasting plants with the lowest animals, he says, "it may well be asked, how is one mass of non-nucleated protoplasm to be distinguished from another? Why call one 'plant,' and the other 'animal'?" The answer naturally would be because they are of different natures, showing that their protoplasm should be different in elements, and because the animal has sensation, the plant none; and usually other obvious distinctions. To call the supply of vitalized food by the same name, without proof that its elements are the same, seems to be a summary way of breaking down distinctions between the different kingdoms of beings and things of life.

Continuing our attention to vegetable life, let us judge the tree by the fruit. Can anybody imagine the resin of the evergreen to be identical with the sap of deciduous trees? The inflammable turpentine to be the same as the watery sap that would extinguish fire? Can the oak and hemlock, whose bark contains tannin, have the same base as the sap of the sugar maple and sugar cane? Can the tea and coffee trees, producing theine, come from the same elements as the palm and olive trees? The gums of commerce, the varnishes, the resins; the spices, cloves, nutmegs; the vegetable coloring matters; tobacco, opium, hashhish; and cinchonia and all vegetable drugs; it is impossible to believe that all these, and plants that produce deadly poisons, had the same base with our farinaceous food, and edible fruits. Theory that attempts to destroy these distinctions by a few observations so narrowly based as that in question, must meet with deserved incredulity, by mankind. The canon of legitimate induction is violated. A similtude of molecules presented to the vision by the micro-

scope, that tells nothing of their inherent properties or proportions, cannot determine the base of plants to be the same, when their qualities as medicines, coloring material, or nourishing food, or poisons, are infinitely varied and the opposite of each other.

This physical basis of life that is thus extended so broadly, Huxley, in a measure, defines, by saying, "that as all protoplasm is proteinaceous, or, as the white, or albumen of an egg is one of the commonest examples of a nearly pure proteine matter, we may say that all living matter is *more or less* albuminoid." Well, that may be, if sufficient latitude be allowed to the words "more or less," and yet all be as different as the things above enumerated, with many other things of contrary elements constituting their "living matter," for all that is not albumen must then be something else, and be part of the living matter that came with the albumen, or protoplasm, into the composition of the living being or thing. And this lets the theory fall to the ground. A partial similitude will not necessarily constitute identity. The theory demands too much when it requires identity of elements of growth in plants and animals of whatsoever kind.

The plant unsentient, without mind or will of its own, is said, by naturalists, to affect its *habitat*, that is, to choose where it likes to grow. This but means that it flourishes where circumstances most favor its growth, and does not elsewhere. In its life inhere wonderful mysteries that we can only refer to something above it, as we have for the life and instinct of animate beings. Its seeds are boundlessly strewn; but which shall grow and flourish, will depend upon their relative power and mastery over competing plants. This contest and its results we readily understand. But how the fibres of the roots have their gift to select from the soil only those particles of nourishment which suits the plant's growth; how the plant can convert silt into flowers; how it can send the vital current, against the law of gravitation, to the topmost branches of the oak and pine, surpasses our comprehension. We say, in part explanation of the latter, that the resin and sap pass upwards by capillary attraction, as we see water rise a limited distance in very small tubes, or through a sponge, or among the hairs of our shaving brush. This, in part, may suffice, but there must be help from vital action, as certainly there seems to be where life is employed in the fresh growth of annual plants, and the new branches of trees. The vital force must do the work, as when that is quiescent nothing is done. As in all animate nature we can only continue to look upon all vegetable life as a continuing, insoluble mystery; but of the highest beneficence. Trees and plants, ever true to the life and duty assigned them, will furnish to man, beast, fish, reptile, bird and insect, the food they require; and to man the medicines, gums, dye-stuffs, and spices he wants; and also the blossoms, flowers, and scenery he loves and enjoys with an ever-refining enjoyment. In truth, directly or indirectly, all the animate life on land, or in air or sea, is supported by the seemingly self-sustaining life of the vegetable kingdom. The latter is created that the former may live; and all, that human souls may crown the creation. Yet

all vegetable life, as all animal, now existing, judging by all we see or know, are the continuous threads of the first created life of their respective species, kept forever unbroken and unentangled.

And as every species in vegetation selects and assimilates different elements from the soil or air, and for different parts of itself, as wood, bark, leaf and flower, so does every different species of animal select those essential to its own well being, and to complete the creature that the life is busy in constructing, and it does construct, but that the parent was. These ends demand differing elements; and however seemingly alike their protoplasm and blood, those and whatever else is tributary to the varied growth and differing developments, must be equally different. It is vain for science to say to the common sense of mankind that the cells that compose the bone and cartilages, tendon and muscle, the tissue, skin, hair, all opaque, and transparent eye, are identical in material, more than in shape or function, or fruit. The sight, the tests of chemistry, commercial scrutiny and scientific classification, alike contradict the theory, and tell us it cannot be true that the protoplasm or blood of animal and vegetable, and every kind of each, can be the same. The young of the mammalia drink milk drawn from the mother: and the milk of the different kinds may look much alike, yet not be identical, and not alike be suitable to nourish the young of all. We may take leave to regard it as a myth that Romulus was suckled by a wolf; but will implicitly believe that neither "do men gather grapes of thorns, or figs of thistles."

It is of necessity that all animals and vegetables that have a vital circulation must take their food into their circulations in fluid form, that it may thereby traverse the body, and in sufficient minuteness supply its wants of growth and repair where needed. The stomach of the animal elaborates the solid into fluid; the roots of the vegetable take up the material it wants, assisted by the rains and water that gives the required transporting fluidity. But that each process sends into the circulation the same elements for animal and tree, there is not furnished the beginning of any proof, while the different natures of the growth indicate very surely that their wants are not the same, that their supplies are different, as their products are infinitely diverse. It must, therefore, be misleading to maintain the theory "that all living powers are cognate, and that all living forms are fundamentally of one character." There is yet a vegetable kingdom and an animal kingdom, and those infinitely diversified. "There *is* one flesh of man, and another of beasts."

Seems it tedious and unnecessary thus to have traveled over the grounds of this theory in so much detail? The conclusion to which it is carried shows how important it is to have carefully considered every foundation-stone of the superstructure. It concerns man the most deeply of all questions to know what he is and what he is to be. That such question is involved, is shown by the conclusion at which the theorist has arrived. In his own estimation he has proved the protoplasm of the vegetable and animal, animal including man, to be the same. Thus Professor Huxley

says: "As I have endeavored to prove to you, their protoplasm is essentially identical with, and most rapidly converted into, that of any animal, I can discover no logical halting place between the admission that such is the case, and the further concession that all *vital action* may, with equal propriety, be said to be the result of the molecular forces of *the protoplasm* which displays it: And if so, it must be true, in the same sense, and to the same extent, *that the thoughts to which I am now giving utterance, and your thoughts regarding them, are the expression of molecular changes in that matter of life which is the source of our other vital phenomena.*" Is there anything of uncertain sound in this? He expects from it the outcry of "gross and brutal materialism;" and then confesses that "*most undoubtedly the terms of the proposition are distinctly materialistic.*" What more he next says, I will show hereafter.

Thus the logical climax of the theory, the capstone of the edifice, appears to be that the thoughts and mind of man, being derived from the same protoplasmic source as the lower animals and the plant, and the physical organization being thence built up, it is consequently to follow, that when the life of this body shall be dead, there will be no mind, no soul, to survive; that it can only with truth then be said, "the bubble of life has burst!" Such would be the natural conclusion of mankind from such premises. And if such be the import of human life, what then is the worth of creation! Must the dignity of man, and the glory of the universe, and the exalting faith of the immortality of the soul be thus cast down, and shorn of their grandeur, and of their logical significance, because the works of the Almighty show some faint resemblances in the early processes of life? That because He makes matter subservient to life, and life to the mind or soul, that, therefore, all must be matter, and all but matter? If such be the logic of creation, as only now found out by very limited applications of the microscope, it would seem to be wise in us to wait a thousandfold further applications of that instrument to the invisible elements of life; and not the while refuse to use our eyes and the telescope as to what they can see, and also to use our understanding and its logic as to what they can clearly know, before we surrender our faith in all that humanity, in its best conditions through the centuries of time, has taken to be the import of our being and the meaning of the universe.

Happily, however, for our relief, so far as his authority will avail, Dr. Huxley makes the admission that, while he is logically carried to a materialistic conclusion by his philosophy, he is, in truth, no materialist, and that materialization would "paralyze the energies and destroy the beauty of life." He has perceived within himself a nobler sense of the import of his being, that arrests his individual conclusion, and deflects his logic, so confidently asserted, into an opposite direction. That is well, and some comfort; but may we take his mere opinion as adequate counterpoise to a theory he has advocated with elaborate detail and apparent earnestness of conviction? Those who love skepticism will continue to abide by his theory, which he has not himself controverted.

In one half paragraph he confesses to a contradiction—to two opposite conclusions: that the theory he has announced as logically true, he himself does not believe! Thus he says: "And, most undoubtedly, the terms of the propositions are distinctly materialistic. Nevertheless, two things are certain: the one, that I hold the statements to be substantially true; the other, that I, individually, am no materialist, but, on the contrary, believe materialism to involve grave philosophical error." Dr. Huxley has not said this to accommodate himself to the orthodox opinion of men. He who takes occasion frequently to encounter and brave that opinion cannot thus have insincerely conformed to it. He is obviously too candid and too brave for that. He seems in all his conduct to follow what he takes to be the truth, fearless of consequences. But what, then, must be our judgment of him? Can it be other than this: that he is possessed of a truer logic, based upon vastly more facts than the few embraced in his protoplastic theory; and that his individual belief, for which he has not given us the grounds, contains the actual truth; and that, consequently, we have Huxley's authority to condemn emphatically Huxley's theory, built upon "the Physical Basis of Life." But who will answer for his insincerity to the truth of science? For the consequences of the infidelity he has preached in his sermon? He proposes to conduct his hearers out of the slough, into which he confesses he had plunged them, and meant to plunge them; but we read on to the end of the discourse in the vain expectation of finding the stepping-stones that would conduct us out of the slough to the firm land. Does he not in this trifle with his own and the understandings of men? His philosophical speculation is one thing; his individual opinion is another. He describes no mitigated materialism that represents his own conviction. That which he has explained makes his uttered thoughts but matter; for these, he says, "are the molecular changes of that matter of life which is the source of our other vital phenomena." And this is his hopeful and confident assertion: "And as surely as every future grows out of past and present, so will the physiology of the future extend the realm of matter and law, until it is co-extensive with knowledge, with feeling, and with action." Thus the science of the physical basis of life is to absorb the mental and emotional, and make all one, all physical;—all to have but a physical basis and a physical consummation. And yet, again, he confesses to two hopeful beliefs, but flagrantly at variance with his pretension for physiology: "The first, that the order of nature is ascertainable by our faculties to an extent which is practically unlimited; the second, that our volition counts for something as a condition of the course of events." Yet neither of these could, logically, be a true belief, if man be but the product of matter and law, and these be taken as sole sources of his knowledge, feeling, and action; for all would yet be fatalism as well as paralyzing materialism. Indeed, there could be no thought, if all were matter. Mere changes of molecular matter could not be means to expand our knowledge, or rule the course of human events. What would it be to the world and its events, that the material of my brain had un-

dergone molecular change? Thoughts are not material growths; are not buds or sprouts; are not protuberances or indentations, or engraved lines; or secretions or excretions of matter, or the shifting of any molecular living particles, by any testimony ever presented to the human mind. Men cannot conceive that matter can be thought, or thought matter; and all its phenomena declare it unlike all else in created nature, and without element of matter. The mind of man has, indeed, a likeness unto God.

Dr. Huxley says, "the fundamental doctrines of materialism, like those of spiritualism, and most other 'isms,' lie outside the limits of philosophical inquiry;" says, "it is also in strictness true, that we know nothing about the composition of any body whatever as it is." But is not all knowledge within the limits of philosophical inquiry? And, though we cannot know how matter, or life, or mind can be, or what in essence they are, yet we certainly can and do know much of the properties and actions of each and all of them, and of their differences from each other. We must not become so far positivists as to refuse to know all that is knowable; and especially may we not ignore the human mind. It is our duty to search after all attainable truths, and when we have come to the limit of our faculties, there reverently to pause, in the presence of an infinity of knowledge known only to God. To seek knowledge only of things physical, and things of life, and there to set the limit of inquiry, seems but the prudery of scientific caution, that can win no credit for wisdom, nor increase our trust in the authority of the teacher.

In this discourse we have assumed that, in its origin, life had a Creator, upon the logic that such effect must have an adequate and a far-transcending cause. As matter and life logically demanded a Creator of each, and neither produced the other, so does the mind or soul, by even higher claim, logically demand a Heavenly Father. Its nature is too distinguishable and transcending to be confounded with matter or life. Life dominates matter, mind dominates them both, and God them all. The soul asserts a higher than a generated parentage, and a large immunity from the mutations of matter. Matter ever slides from under mind, but its integrity is untouched. The matter that has sustained the life of one as old as the writer, has wholly passed away from his body more than ten times; and the more rapidly changing parts have been eliminated with vastly greater frequency. Yet the mind in this body has a memory of conscious identity from the year next before the first of the current century. Such imperishable mind can have no element of ever-shifting matter in it; and must be a being of different origin and nature, both from the material of this body and the life of this body. That material is ever changing, and is often renewed, until the body's death; and when the life that maintained the organization shall have succumbed, and have ceased to exist, except as it has been continued in a living progeny, we justly infer that the mind, or soul will outlive the organization and the life, and will return to its Giver, to share His pleasure, or meet His

condemnation, as deserving. This is inferred from what we know of the nature of mind, and the induction that creation must have an adequate significance. The great truths of Scripture are inductively reattested by the truths of philosophy.

Thus, then, stands the phenomenon of our being. The matter that enters the body may be, in itself, for all we know, imperishable, but is certainly transient in each living body; remains there until effete, and is then dismissed by the vital process; or at death passes into vapor and ashes, and enters the further rounds of chemical change and vegetable and animal growths. The organized being of one generation of the life of an unbroken continuity from the first parents has come to an end, except as continued by offspring; but the individual, ungenerated, immaterial mind, that was neither the matter nor life of the body, lives on forever.

We have seen the life assert a dominating power over all the material that has built up the organized body. This life process is essentially one independent of the mental will. During gestation this is plainly so; and is so through life, except as the mind has power to refuse to conform to the laws of health, and may mar life's healthful functions and duration, even to the perpetration of suicide. The circulation, digestion, assimilation, and eliminations go on in health almost without our consciousness; but we are compelled at intervals, by hunger and thirst, to keep up the needed supply of food and drink. The brain and nervous system are also thus nourished, as the rest of the body,—though it is the system especially subjected to the instant dominion of the mind or will. The material brain and nerves are not the mind, nor do they produce it, but are servants of the mind. Mind is other than the brain and nerves, and is other than the life; and it alone can rule, and must give account of itself,—the body, and the life. The vegetable carries on all its given life-processes, without sensation and without mind. The animal below man does the same, except as it has a limited mental development that we call instinct; has also, limitedly, brain and nerves, and senses; all of wonderful fitness for its preservation, which we may not now pause to consider. The life of plant or animal will grow to its assigned limit; will cure its own wounds, and reproduce its kind; but is other than the instinct of the animal, yet more remote from the mind of man: it alone, of all beings, has moral responsibility.

Among the hundred or thousand wonders of the life, whose casua explanation can be in Deity alone, and over which mind had no formative power, is the fact that every kind of nerve has been fitted for its special duty, and can perform no other. There is, in this, admirable design to prevent confusion. The nerve of sense can give sensation to, but can impart no mandate from the mind. The nerves that execute command will give back no sensation. One of each is attached to each serving muscle, but neither can do the appointed work of the other. The nerves of sight, hearing, taste, and smell, can neither of them perform the func-

tion of any other. The brain, the commonly supposed seat of all feeling, has in itself no feeling. Sir Charles Bell says: "The brain is as insensible as the leather of our shoe; that the brain may be touched, or a portion of it cut off, without interrupting the patient in the sentence he is uttering." The brain and the sensitively perceiving mind must, therefore, be different. The one is cut away; the other suffers thereby no interruption of thought or its expression. One feels; the other does not. One commands; the other obeys. The muscle is moved by the will and exerts great power, but through a brain and a nerve without muscle, or physical power, so far as is seen. Apparently an immaterial mind says to every muscle, do this; and it doeth it, but by the word of command. Truly, the body, life and mind, each, is very wonderful, and most wonderful is their combination; a combination of dissimilar things, made to act in antagonism, and yet bound to act in harmony, for the welfare of all. Awake, the mind is to regulate all for the common good, yet may not, without injury, much interfere with the life-process of the bodily organization. Asleep, the physical reacts, taking a limited advantage of the unwatchful mind that has let drop the rein of discipline. The mind, in the semi-consciousness of dreams, ranges through bright scenes and beautiful images, if all be well with mind and body; but if either be unhappy or disordered, a dark change comes over the happy dream, and then threatened dangers and startling incidents awake the mind to resume its discipline; happy then to find its troublous adventures "but a dream." Yet, in the sleeping and waking experience, the mind and body have acted and reacted, both as united, and often as opposing powers.

The materialist sometimes ventures even to liken life to a process of crystallization or chemistry, or mechanism, and mind as well. Crystallization follows one law, and, the world over, does one thing, and forms its crystals and gems of each kind on the same angle; her ultimate particles of the same kind being of the same shape, and obeying one law of attraction. The chemical affinities act under laws as certain, and under the same circumstances act always in the same way. Living things are more complicate; and the process of growth is carried on by an apparent choice as to the selection of material and in the deposit of different particles, for the growth of the several parts, differently from crystallization and chemistry. Life is not molecular, or magnetic, or chemical attraction; but is a vital process that employs various materials; utilizes them, and disposes of them differently to perfect the common economy. It employs, it is true, chemical processes in breathing, etc.; and in the heart, eye and ear, and in the action of the muscles, mechanical structures and powers; but all is moved by and independent upon the life that has made from matter living molecules, and with them constructed the creature. But all this, though subservient to, gives no explanation of, the mind; shows no kindred to it; gives no information why we have consciousness, how we can feel and think. No proof is offered, nor can, it is believed, be adduced, to show that the mental action consists in but physical changes. The

brain, as the arm, may show weariness when overtasked by the mind; may suffer waste of material, of phosphorus, if you please; but that will not prove mind to be brain, or brain mind.

The all-transcending importance of this subject demands our yet further patient consideration. On the discrimination of the mind of man from the body and from the life, depends our truthful apprehension of the great problem of what we are, and what we are intended to be,—the most important consideration that can occupy the human mind. Can we, as rational beings, live over threescore years and ten, or more, and not devote much of our time to reflect upon this subject, the highest of philosophical studies? This is not an "ism" lying outside philosophical inquiry. No religion can begin her task, no philosophy can consummate her study, that has not persistently dwelt upon it and made it the theme of habitual thought. It is the necessary climax of all the study that can give us the solution of the problem of the universe. In this age of materialistic skepticism, that respects no time-honored opinions, or sacred traditions, we must begin where the physicists begin, but may not stop where they are wont to stop; may not refuse to know the ultimate significance of all created things and beings, body and soul, as they are constantly presented before our senses, and demand interpretation from our reasoning intellect. We may not fail to examine and consider all the true facts that the naturalist and physicist make the basis of their theories, nor all other facts that must be taken into view, for a true solution of the problem. No *a priori* assumptions may be admitted as bases of induction; and it must not be allowed the skeptic to say, as he is sure to do, that he only builds truly upon certain facts; that his faith alone stands in inductive truth; that religious faith will not bear the test of induction from ascertained facts. And we must not permit him to make his inductions from less than half the facts that define our being, and these the less important.

The mind's thoughts are not propagated as things of physical growth. We but borrow, in relation to the mind, the language of the garden, and use it figuratively, when we speak of sowing mental seeds, or propagating ideas. The thoughts I am speaking, I do not lose; and your gain, if any, is not a material acquisition; nor, so far as you or I can ever know, has the effect been produced by molecular changes in our brains; and if such changes do take place, they are a life process of the brain, and cannot, conceivably to us, be the thoughts that enter into and exercise your minds; thoughts that, as believed worthy, or as your minds may make them worthy, may become permanently your thoughts, after the molecular particles moved, if any such, will have long passed away. The mind may, indeed, for aught we know, and we may so conjecture it probable, put the brain in motion, as we know it will thrill the nerves, and can hurry the blood; as the wind can heave the water into waves, but the cause and the effect are different, and continue ever after as distinct as before.

Physiology teaches us that the mind is seated in the brain; for with the

brain is connected every nerve that gives to the mind the sensations received by it; and with the brain is connected every nerve that executes the will of the mind upon every muscle of the body movable by the will. A ligature round the nerves of sensation will prevent the mind receiving sensations by them from a point beyond the ligature; a ligature round the nerves that obey the will, will paralyze its power to command the muscle to which the nerve is attached. The perception and command are intercepted at the ligature; and beyond mental power has ceased. The mind, that is the light of our being, sits enthroned in a chamber of life-long darkness, cushioned upon medullary matter; moved by no muscle, yet moving every motor muscle as bid to obey its will. The eyes are called its windows; but that is to speak figuratively, for no ray of light ever enters there; the senses are called its portals, through which we learn all we know of things without us, but no sense ever lets into the mind one particle of matter.

We have seen that the life of the body is fed by material food taken into the stomach. The mind is not so fed, nor fed by any material food. The mind, or a mental capacity, exists in a child at birth, underived from sensations, for it must pre-exist to receive the first as all after sensations. Though we may not know how it can exist; of its nature and operations we can observe and know as much as of matter and life; and we have no more right to refuse to know all that we can understand of it than of them. It is the nobler part of our being, and that which is most characteristic and most prophetic of the purpose of existence.

The immaterial mind is fed but with immaterial food. It draws this from sensations without and within; and thus learns the nature and qualities of all perceived things. It digests that it receives; forms conceptions or ideas by its inherent power; has capacity of comparing, thinking and judging, and thus is also self-fed from within by immaterial thoughts as no life is fed. Thus we may observe the mind to be developed; the mind that can frame the constitutions and laws that preserve human society, and that can administer them; that can wield the physical arms and resources of the nation; and can develop the truths of philosophy and religion. All this is done by thought, only by thought; by thought, indeed, sometimes inspired; and the quieter the body and the brain, the more surely truthful is the mental judgment and the might of its power.

Now let us consider some of the sensations that the mind notices as perceptions and conceptions, and stores as ideas, to be used in thought and judgment, and see if they own a material source. The eye opens upon all visible things, and by a lens the picture of them is represented on the retina, or back part of the globe of the eye; a picture the reverse of that in the outside world, upside down, right side left. The retina is the expansion of the optic nerve leading to the brain, that gives to the mind a perception and conception of the image on the retina; not that the image can itself be taken through the round opaque tubular nerve; not that there is any material picture on the retina, any more than the reflection from the mirror is a real picture on its surface: but the mind has capacity

to reach forward and take perception of the picture truthfully, but takes it restored from its reversals by the convex lens to its true position, as was the outside reality; up-side up, and right-side right, as is at once verified by the outreached hand. This power of perception is something more, and quite different from, the materially-fed animal or tree. There is no protoplasm here. The perceptions, and the ideas thus derived through all the several senses, are alike immaterial. Through the eye, the ear, the touch, taste, or smell, it is not perceptible, nor conceivable, that outside matter enters into the brain, yet less into the perceiving mind. It seems more reasonable to infer that the mind, which by its will can command and put in action the many muscles of the body, through the nerves of command that extend from the brain to them, can also reach through the distinct system of the nerves of sensation, wheresoever impinged upon, and take note of all sensation. Thus doing, the mind is filled with perceptions, conceptions, ideas. But when it perceives, thinks, compares its ideas, recalls its memories of long past years, forms new judgments, and the will sends forth its mandates, we are not to believe it is carrying on material operations, before the muscles have acted; that thoughts are the bubblings or heavings of medullary matter; or as electricity they are elicited by material friction; or as the chemical corrosions of a battery; or are any other material production. There appears no evidence of any such processes, and these indicate no relationship with mental action. The memory of half a century ago cannot be a recalling of the matter of the brain of that time; the perceptions taken into the mind contained no material element, and the mind's elaborations of immaterial perception cannot be elaborations of matter, or produce material thoughts. Thought that ranges instantly over creation cannot be bound by the limitations of matter. Whatsoever is matter must have the bounds of matter; matter must have the properties of matter. Thoughts are not so subject. It is not in the nature of matter to range beyond itself; to look to the past or future, or in imagination to survey the world and universe, and all that in them is. It is not in the nature of thought to be subjected to mechanical or chemical tests. If thoughts be but matter, they must be eliminated by the body's ever busy absorbents as waste material, and there could be no memory of them; but the mind holds not her rich treasures by so slight a tenure. The intellect would then sit upon a throne whose base would be incessantly undermined; nay, be rapidly swept away, since the new tissue supplied to the brain by the life-process would not replace the lost ideas. Immaterial thoughts, the immortal mind, is not carried off as waste and effete matter; as sewage through the sewers of the body. Newly-deposited brain tissue from the blood would not restore thought that has vanished. Memories are not as characters written on the sand, to be washed out by ever refluent waves. The memories of a well-preserved old man, whose strength has not failed, nor his eye grown dim, make him a being compounded of the characters of three generations; with mind informed by the pressures and knowledge of

them all; with gathered experiences and forethought that make him largely prophetic of the future. So the poet's vision has seen and described such an octogenarian; or knew him, and sketched him from life:

> "Age had not tamed his eye: that, under brows
> Shaggy and grey, had meanings which it brought
> From years of youth; which, like a Being made
> Of many Beings, he had wondrous skill
> To blend with knowledge of the years to come:
> Human; or such as lie beyond the grave."
>
> —*Wordsworth.*

As the visual picture entered not the brain, so will not the vibrations of sounds in the air. The speaker's mind is filled with thoughts which he is earnest to inculcate upon his hearers, and vocally he gives them to his thousand listeners. I do not say *transfers* them, for he has not parted with one idea, though they have got all he has spoken. No phosphorus, or any other matter has left his to go into their minds. His voice has but made vibrations in the elastic air, which otherwise has been unchanged. These vibrations have spread concentrically from their centre, with their ten thousand distinctions of modulated words. These sounds have reached the ears of the listeners, and their perceptive minds have reached forward through the auditory nerve, whose extension by delicate fibres floating in the water of the vestibule of the ear have been stirred, and given to the mind the perception of every variation of the voice of the speaker; of its formed words, its inflections, cadences; its tones of earnest pathos and its joyous or sad emotions; and all its varied meanings. But no vibration of the air has reached the interior of the brain; indeed, no material idea had traversed the air to reach the hearers. Air-borne wavelets of words, or conventional signs of ideas expressed only by distinctions in sounds, have reached the easily moved hairy fibres of the auditory nerve, and imparted motion to them; but there the material motion has ended, yet the perceptive mind has caught the many distinctive meanings. But no motion, no sound, no matter, has entered the brain by the auditory nerve; for the nerve there embedded is constricted in passing through a narrow orifice in the skull; is not itself floated, or tensioned, to transmit vibratory motion; but cut off from the air, the vibrations of which have been spent upon the drum of the ear and the wonderful apparatus, and water within the vestibule; and were this not so the vibrations of the air are not transmissions of matter; but when the voice has sounded, the air and the ear are again as if no voice had spoken. The mind has taken the perception of the distinctions of sound from the fibrous extension of the auditory nerve. Had the same words, or conventional representations of thoughts, been written or printed, and then been read by others, these would have received their characters pictured on the retina, without the charms of vocal expression, and alike without the reception of any material element in the brain.

It is obviously the same as to the sense of touch. The finger will give the perception of the shape, density, temperature, etc., of the object

touched, but no matter or thing will be transmitted into the brain. The mind, by its perceptive power in the brain and nerve, will have taken notice of the properties of the object, and formed an idea of it. By no sense has the brain or mind been materially fed. Here we should recollect the physical condition of the brain. It fills the chamber of the skull; is always dark, is always silent. Therein is the source of all the intellectual light in the world, yet not one real spark, or beam of light has there ever glowed. No ray of light can depict a picture therein; no vibration can carry a sound within it; no tasted food, or touched thing, nor aroma of incense, can enter there. But the nerve of each sense has been affected by an outward object, and the perceptive mind has reached to notice the action of the outward thing upon the nerve. In the eye it is a picture thrown by the light on the retina and it is there perceived; in the ear vibrations have stirred the floating fibrous extension of the auditory nerve, and there they have been perceived with their varied distinctions; and by the other nerves of smell, touch and taste, the perception has been at the point of contact. The mind's command reaches by the motor nerve to the remotest muscle: sensation by touch may reach as far; and there appears to be no reason why the mental perception has not reached to the point whence such sensation is said to have come. The mind wills to move the toe, and it has at the same instant the perception that it has moved. Indeed, each nerve of sensation has its local duty to inform the mind instantly of every impingement upon the surface over which its fibres are spread. This it can only do by the mind's taking notice of it, so that sensation implies perception. The nerves at the stump of an amputated leg, when irritated there gives the perception as at the foot or toe to which the nerve when unsevered had been attached, for that had been its established duty in its relation with the mind; and the perceptive mind yet adheres to its original consciousness, and still takes its perception as from a living foot, where now there is none. The perception that had formerly reached the extremity of a perfect nerve comes to consciousness as from that point, though the nerve has been touched midway. And when the optic nerve is involved by disease, its illusive visions produced by disease, appear as they would, if truly pictured on the retina; and so if the auditory nerve be so involved, the illusive sounds appear to enter the ear. And so, too, as to those bright visions and hymning tones by which the dying are often preternaturally visited, showing them, in advance, celestial scenes and companionships such as they are about to enter, their outward senses seem to them still to have served them, and they wonder that their surrounding friends have not seen and heard all that they have so intensely enjoyed; but no outward sense had seen or heard all that the mind had directly perceived. The appropriate nerve always ministers to the mind according to its original appointment, and responds as the faithful sentinel, only from the assigned post of duty, and there it is that report is made to perception. Sensation and perception appear to be synonymous and simultaneous, and at the same point; but the conception of ideas, and the mental processes of thinking, comparing, imagin-

ing, judging and willing, are carried on in the superior brain, by which man is distinguished above all other creatures. Physiologists speak of the sensorium or central ganglia, below the cerebrum, as the common centre of sensation; but our own consciousnes when thinking, and our penal headaches for over-much thinking, plainly say to us that the crowning and frontal hemispheres of the brain are the seat of thought and mind. It is the mind in that little space that rules the world.

The reflective anatomist as well as others, is struck with wonder when contemplating the human brain as the seat of thought and sovereign will; yet as poet he must speak figuratively. He exclaims as he looks upon it,

> "Then mark the cloven sphere that holds
> All thought in its mysterious folds:
> That feels sensation's faintest thrill
> And flashes forth the sovereign will;
> Think on the stormy world that dwells
> Locked in its dim and clustering cells!
> The lightning gleams of power it sheds
> Along its hollow glassy threads!"
>
> —*Dr. O. W. Holmes.*

Such combination of body, life, mind and feeling, are indeed, more wonderful than miracle, and justify the anatomist and poet in his prayerful conclusion:

> "O Father! grant Thy love divine
> To make these mystic temples thine."—*Ib.*

The great fact is never to be forgotten, that the body is fed only by material food; that the brain and the nerves are also fed as the residue of the body from the living blood; but that the mind is ever and only can be fed by immaterial perceptions of outward and inward material things, and as it is self-fed by its own immaterial thoughts and inherent emotions. How amply the physical brain is fed by the blood, is apparent when physiologists tell us, that its proportion to the whole body is as one to thirty-six, while one-fifth of the whole volume of blood is in circulation there.

There is another test we may also daily observe in others and in ourselves, showing that mind and body are not alike nourished, namely, that the gross feeding that expands the body, does not enlarge, but obscures the mind. That the mind is usually clearest and most effective when men are abstemious and temperate, provided only they eat enough to keep up their normal strength. Many bright minds that have enlightened the world, would never have been its shining lights, had not their bodies been frail and their physical organization delicate; indicating, not that the body and mind were one, but that the body's grossness had not overlaid or obstructed the free thinking and reasoning mind.

The power of mental consciousness and his capacity to think, constitute man's great distinction. Mind makes him man, and lifts him above all other creation. It is the mind that yields him all his purest and truest pleasures. We say that the eye sees, and the ear hears. These senses are but inlets to outward sights and harmonies; it is only the mind that per-

ceives and enjoys. The transporting prospect we look upon; the landscape of lawn, trees, river and mountain; or the music that charms us with indefinable delight, are pleasures inherent in the mind, inborn of the soul. Led by the great dramatist, we willingly say with him,

> "Here will we sit, and let the sounds of music
> Creep into our ears: Soft stillness and the night
> Become the touches of sweet harmony!"
> "Such harmony is in immortal souls."

And such inner sense of the beautiful; our moral sense; our sympathy with our fellow beings; our emotions in worship; "our sense of an endless being;" are all inborn of the soul, and assure us ours is the harmony of "immortal souls." Necker, statesman of France, also reassures us of what Shakespeare so beautifully said: "The whisper of the gales, the murmur of waters, the peaceful agitation of trees and shrubs, would concur to engage our minds, and affect our souls with tenderness, if our thoughts were elevated to one Universal Cause." It is thus in thought and emotion that alone we can rise to commune with our higher self, with the highest endowments of our friends, and with Deity.

The materialist supposes he has advanced his theory when he tells us, that it has been found, after a speaker has used extraordinary mental exertions, an analysis of his urine shows an increase of phosphorus; and this is inferred to be a material residuum of the speaker's spent thoughts! The idea must be that phosphorus is the matter most likely to be mind. Let us apply another test, not material, to this supposed experiment: the scrutiny of the thinking mind itself. The exertions of the speaker were probably much more physical than mental, and the result, if true, would be more properly assignable to physical causes. The ideas of the speaker are commonly formed in advance, in his study, in quietude, and the best of them in the wakeful hours of the night, when the body is in perfect repose. The delivery of them so far as the intellect is tasked, is more the easy exercise of memory than the formation of new ideas. But to make the delivery of them impressive, the orator exerts his voice; gives violent play to the lungs; uses earnest gesture; accelerates the circulation; produces perspiration; and it would be an obvious consequence, even if there were no increase of the phosphoric deposit, that as much of the water in the blood has gone out through the pores of the skin, which would otherwise have diluted the urine, that the phosphorus appearing in it is found in larger proportion.

Though matter be essential to the growth and transmission of all life; though matter and life be essential to sustain the mind in its manifestations in this world; all these three are of very distinctive nature. In the plant there is life, but no brain or nerves, nor feeling or mind. These, therefore, are not necessary to the phenomenon of life. It is the nourished blood of other composition than vegetable protoplasm that must flow and bear the life-sustaining material of the animate being, and that for brain and nerves as well as the residue of the body. You may intercept the mind's perception, and life will go on; but intercept the blood's circula-

tion and the excluded part is killed. Sir T. C. Morgan, M. D., says: "If the supply of blood be cut off from a limb, by means of ligatures made upon its arteries, sensibility of all kinds is in a very short time extinguished; and the part dies, and undergoes the same changes, as supervene on the death of the whole body." "If, on the contrary, the circulation continue uninterrupted, and the ligature be cast round the nerves of the limb, so as to cut off its communication with the cerebral centre, the other tissues will continue their functions uninterrupted by the accident." "These counter-experiments clearly demonstrate that the nervous system is not the fountain of life to the rest of the economy; but receives its animation, in common with all other tissues, from the action between its own vessels and the circulating fluids." (Philosophy of Life, 217.) Thus the incomprehensible life requires matter as the vehicle of its manifestations; and the incomprehensible mind requires matter, including brain and nerves, as well as the life, for its manifestations; but the distinctly manifested actions of both are full of diversities and contrarieties. As life cannot account for and produce matter, nor matter life; so do neither, or both together, account for, or produce mind, but only subserve it. For each the Cause can only be logically sought in a Creator; and for their wonderful combination, and concurring, or counter-actions, in the being man, we can, in reason, only refer ourselves to Him who transcends all and knows all, even the thoughts and mind of man. That mind that is not matter nor the life, but is above these; that has no likeness on earth; proves itself of all we know the most like unto God who is a spirit. It alone in nature reviews its own consciousness, as under an inevitable sense of moral and religious duty and accountability, and asks and answers the question, "My soul, is it well with thee?" If there be another such being in the universe, it can only be an angel in heaven.

Xavier Bichat, who studied and wrote at the end of the last century, and until the second year of this, and had much experience in surgical practice during the French Revolution, was certainly the profoundest physiologist of his day. He did not fail to perceive that the human mind was something different and higher than the brain and the nerves, which he regarded as but material instruments of the mind. He considered a want of harmony in the two superior hemispheres of the brain as cause of imperfect perception, not by the brain, but by the mind or soul, saying, "for the brain is to the soul what the senses are to the brain; it transmits to the soul the impressions conveyed to it by the senses, as the senses convey to the brain the impressions made upon them by external objects." (On Life and Death, 30–31.) "If both (the hemispheres) do not act alike, the perception of the mind, which ought to be the result of the two sensations united, will be inexact and irregular." (p. 31.) He inquires, whence arises the facility which our sensations have of undergoing so many modifications, and answers: "To conceive of it, let us first remark that the centre of these revolutions of pleasure, of pain, and indifference, is by no means seated in the organs, which receive or transmit the sensation, but in the soul." (Ib. 49.) Thus imperfect perception and

apprehension, and, indeed, imperfect intellectual powers come from defects in the material instruments that serve it; but it is to be said that the defective structure produces deficient mind only in the sense that it has served the mind with imperfect perceptions, and hence with erroneous conceptions for its use. The nature of the mind may thus be the same in all, though furnished with perceptions and ideas, and exercised and developed, as variously as the number of human beings. Then, again, the physical constitution and the animal passions, as well as the emotions and effections, social, moral and religious, will also differently affect the sensations, perceptions, and powers of reasoning; our thoughts, imaginations, judgment and character, and yet not be the mind that thinks, reasons, judges, and acts. They are most important parts of the being; but the physical can be no part of the mind.

Yet Mr. Huxley tells us that our thoughts "are the expression of molecular changes in that matter of life which is the source of our other vital phenomena;" but he states no reason why this should be so; why matter or life, separately or together, should produce thoughts. He takes no notice of their contrary nature and operations from matter. Now, as we have seen, the process of life gives its own proofs, immeasurably surpassing in accuracy that of the microscope, as to all that enters into the composition of the plant or animal, as attested by products infinitely varied, and thereby has proved all protoplasms not to be *bases* of the same nature, and that life uses other elements in her structures; so the different natures and actions of thoughts and mind from life and matter, must be taken as proof that they are not one with, nor can be produced by matter, or yet be the life that has subjected matter to her uses. The life, instead of producing mind, is made subject to the mind; as to its uses, what it shall be; whether it be more worthless than the festering charnel heap, or in purity, perfection, beauty, and glory, it shall be the fitting companion of immortal immaculate beings.

Professor John Tyndall, always ardent and hopeful in scientific discovery, does not leave the materialist without hope in the future, yet does state this: "I do not think he is entitled to say that his molecular groupings and his molecular motions *explain* everything; in reality they explain nothing." "The problem of the connection of body and soul is as insoluble in its modern form as it was in the prescientific ages." "The passage from the physics of the brain to the corresponding facts of consciousness is unthinkable." (Fragments of Science, 119.) True, the manner of the connection is unthinkable, but the fact of such connection between very dissimilar things, all must admit who do not deny the evidences of their senses, the proofs of experiment, and of the mind's testimony unto itself; and the higher significance of mind and emotion seems equally obvious.

The mind is placed in closest alliance with the body, but is of different constituency and power. Set over the body to rule it, her throne is in the brain, whither the nerves of sensation are ever giving information from without and within; whence her judgments are ever issued, and executed through the nerves of command. Would you liken this to the telegraph?

—you must carry the comparison to include both operator and sender of messages; must note that in the centre is the mind that thinks, and that receives, and sends the messages, and commands and executes as well. There is still the mastery of mind, ever asserting her power over matter, and her own likeness unto God. And though so small a speck, there is nothing known to man that will so bear to be put in comparison with our conception of Deity, who is a spirit, as the immaterial mind of man.

It is not to be doubted, after the experiments and observations of Prof. Matteucci and Drs. Du Bois-Reymond, Carpenter and Radcliffe, that electricity pervades the nerves and muscles of the body; the precise service of which awaits further development, but is supposed to be identified with the ordinary force and action of the nerve and muscle. Dr. Radcliffe says, as the result of his investigations, "There is reason to believe that all kinds of electricity act upon nerve and muscle by way of charge and discharge, the charge antagonizing, the discharge permitting, the state of action." Whatever may be further ascertained as to the agency of electricity in the animal economy, of this we may be assured, that it will act subserviently to life and to the will. So it is found in the electrical eel and the torpedo fish, in which life largely accumulates it, and the will discharges it upon an enemy, in electric shocks, but only so long as the supply lasts, when the belligerent thus armed must await renewal of supply by natural recuperation. With all animate creatures rest after fatigue is the appointed means for renewal of strength to muscle and nerve, to become fitter instruments of the will; and that is to say, after the exacting will has ceased to enforce wasteful action, the life process works on during repose to restore the strength, and the more perfectly if we sleep. The strength or electricity would not be given us without the life gave it, and neither is to be identified with the life, or mind, or will.

I suppose there are few of active mind who have not the consciousness, when going to sleep, of those sudden nervous throbs that tell us that a disturbed electricity is seeking its equilibrium in the body, and thus several times defeating the desire to sleep. This occurs at the moment of obliviousness; showing that the mind had until then restrained electrical action; but which ensues as a physical action in the body, as soon as the mind ceases to rule. Many materials concur to build the human temple and to subserve the life. The blood alone has its more than dozen elements; its water, albumen, fibrin, sodium, lime, magnesia, iron, &c.; and heat and electricity may warm the body, and aid the vital functions, yet be not mind.

And our minds

> "Are not wholly brain,
> Magnetic mockeries;" * * *
>
> "Not only cunning casts in clay:
> Let science prove we are, and then
> What matters science unto men?"
>
> —*Tennyson.*

Prove man is worthless, then is science worthless all.

One so practical and learned as Dr. Carpenter, and so fully informed upon the results of modern scientific investigation, and himself writing as a life-long teacher of physiology, regards the brain as the instrument

of mind other than itself. "The physiologist knows full well, that the immediate operation of the will is not upon the muscle but upon the brain." "We have not only evidence of the excitement of nerve-force by mental agency; the converse is equally true, mental activity being excited by nerve-force." And he proceeds to say, "it is obvious that the view here taken does not in the least militate against the idea, that mind may have an existence altogether independent of the material body through which it thus manifests itself." "In the control and direction which the will has the power of exerting over the course of the thoughts, we have the evidence of a new and independent power, which is opposed in its very nature to all the automatic tendencies, and which accordingly as it is habitually exerted, tends to render the individual a *free agent.*" (Physiology, Secs. 585, 586, 588.)

The capacity of the body is limited. Its growth cannot be forced. It can add not a cubit to its stature. But no limits can be assigned to the acquisitions of the mind. While he has life, man may learn. True, students, ardent and ambitious, will often sacrifice their lives in the pursuit of knowledge: but that is not because the mind has taken into itself more than it will hold, but more rapidly than the frail body will bear, and in manner violating the laws of health; those laws that require the exercise of the muscles, the play of the lungs in breathing fresh air, and an accelerated movement of the circulations, of the assimilative process, and of all life's functions; and due rest and sleep. The versatile and boundless ranging mind must wait upon the limited conditions of its subservient companion; by wisely doing which this life may last long, and the mind ceaselessly acquire increase of knowledge and power. But ever the master mind must be doing, or naught is done.

Dr. Carpenter, as a purely scientific teacher, also speaks of the soul's relation to the Infinite; and of its constituting one of the most distinctive peculiarities of man, and as the main-spring of human progress. He says the desire for improvement grows by what it feeds upon; "in the higher grades of mental development there is a continual looking upward, not towards a mere elevated human standard, but at once to something above man and material nature." He desires to participate in a spiritual existence, of which the germ has been implanted in the mind of man, and which, developed as it is by the mental cultivation, * * * has been regarded by philosophers in all ages as one of the chief natural arguments for the immortality of the soul." (Physiology, Sec. 7.) And he concludes his work on Animal Physiology, in these words: "The philosopher who has attained the highest summit of mortal wisdom, is he who, if he use his mind aright, has the clearest perception of the limits of human knowledge, and the most earnest desires for the lifting of the veil that separates him from the Unseen. He, then, has the strongest motives for that humility of spirit and purity of heart, without which, we are assured, none shall see God."

While I would thus elevate mind to its truthful distinction and pre-eminence, I would say nothing to disparage the material and living creation. While physicists ascribe all to matter,—all matter, all life, all mind,

—and nothing to God, I ascribe all to Him ; yet regard matter as essential means to all life, and to the exhibition of all mind upon this earth. We see God's good design in physical nature, and that design we must reverence, and learn to adore Him in the sublimity of his works. Without this material earth, and sun that lights and warms it, there would be none of the life that we behold—would not be human souls to people heaven. Climate, it is to be admitted, does make the Esquimau and the Negro what they are. Unfriendly to life and its happiest physical development, it is also unfriendly to intellectual, to moral, and religious culture ; and it also fails either in the productions needful for man's uses and improvement, or produces animal and vegetable life so rankly as to over-master the unskilled native, until he shall be helped by the stronger and more inventive man of the temperate zone. But it follows not that the mind is the production of the surrounding physical causes, but only that these have not so well developed the instrument the minds must use ; and consequently the mind itself is not so fully developed.

The mind it is that is ever conquering nature and moulding matter and ruling life. It reclaims the earth to culture, fells the forest, drains the morass, destroys wild beasts ; mines the fuels and metals ; makes and applies iron to its ten thousand uses ; constructs railroads and telegraphs; creates the arts and sciences ; educates mankind generally unto a higher civilization, and makes a large proportion almost what they should be ; that is to say, learned, temperate and wise, lovers of man and worshipers of God ; and all are advanced in moral conduct, except the irreclaimably vicious. The task remaining before our humanity is to endeavor to cause the people to approximate the standard of perfection; and if, peradventure, we get a majority of such, the world will have made inestimable progress. And why should we not all strive for such consummation ? In every branch of business, men exert a wonderful amount of common sense and acuteness of thought, and achieve admirable success. Half the like assiduity and culture directed upon their own minds would produce a transformation of character and increase of intelligence, that would excite their wonder and the admiration of the world. Mind only can do it, but mind can work the consummation; and that is the great hope of all thoughtful, good men.

In all ages men have spoken of matter and mind ; of the flesh and the spirit ; of body and soul, as things of contrasted nature, and as at strife, until one has attained the rule over the other ; and if that rule be of the flesh or the sensual passions, it is a dominion of sure degradation and early destruction ; but if it be of the truthful mind, then is it a dominion of peace and wisdom. Paul said : "I see another law in my members warring against the law of my mind ;" with the sin in those members his sense of duty was also at war : and to desist from fulfillment of the sense of duty, was to him intolerable woe. Mankind have always made such contrast, and adopted their lesson of discipline from the requisition of an exacting conscience, and by induction from surely observed facts. And when our friends are with us in life, what is it that so much engages our attachment and love and veneration for them ? Not surely the body, except slightly by association, since it is the temple where higher excellence

dwell; but it is the intelligent mind, the loving heart, the well-tried virtues. And when death has taken our friend, for what is our sorrow? Not for the body, so little distinguishable from other bodies, but for the intellectual and social companion, who had requited our love, but may never again; that instructor and adviser with whom we took wise counsel, but shall no more on earth forever. It is for the social and good and generous mind that we grieve with a grief that refuses to be comforted, except as we find it in the faith that assures us we shall meet again, never again to be separated; a necessary faith of human consolation, and therefore proof to ourselves that our minds and virtuous affections shall be immortal. This was the testimony of Buckle, as to his own experiences and reflections after he had witnessed the slow decline and death of his beloved mother; testimony that refuted the skeptical philosophy of his life; and has redeemed his memory from apparent heartlessness, and made it very beautiful to those whose philosophy grasps the immortality of the soul.

Matter and life are always undergoing changes, and both, in the human body, kept in health, will live through length of happy years; but at some time they will hasten towards dissolution, and come to the end of their organism; and the life will only thereafter continue as it has been imparted to offspring. But mind or thought is everlasting, if there can only be found imperishable material to hold its expressions. If the printed page, or the canvas, or marble will endure, the thoughts of the author and artist will last forever. The eternal thought can then only be assailed through its allied perishable material; and that mind shall never perish, it only needs an imperishable, a "celestial body;" and that it should be translated into one, or live independently of one, should be no more a mystery to philosophy than that the human soul has existed in its mortal habitation; is not more questionable as within the power of the Almighty and His fulfillment of the logic of His creation, than the fact that a blade of grass shall grow, or that this body is now the habitation of a human life.

The subject of this discourse might be continued through volumes, and the writer be all the while dealing with as veritable realities as those that occupy the physicist or naturalist, whose great deficiency so often is, that he becomes so wedded to the material that he disregards the mental and moral in his philosophizing, and is, therefore, possessed of but half the facts needful as a basis whence to make induction of all the great truths of Creation. He needs to know more to become wiser and more charitable; and the metaphysician and theologian also need to know all the truths of physical nature the former can develop, all of them God's truths, that they may become more fully informed, and, perhaps, more charitable; that they may clearly know the physical works and laws of the Creator, and the more perfectly love and adore Him. Each class is in possession of numberless invaluable truths, but neither possesses so many as it should know; and this is partly owing to the wall of partition their hostility has erected between them. While it is natural that each should cling strongly to its convictions, these convictions must be based upon all facts requisite to truth, that they may endure.

And here let me not be understood as making a general charge of

materialism against physicists, for I am happy in believing that the great majority of physicists are not materialists. I give credit to all who disavow a materialistic faith, including Dr. Huxley; giving credit to the like disavowals here, there is no materialist known to me in this Society. I have been enabled to use the authority and facts furnished by eminent physicists, with great advantage, to sustain the views expressed in this essay, as those of Bichat, Morgan, Carpenter, Holmes, and Tyndall.

While the drift of Professor Huxley's lay sermon favors materialism, there is that in "systematic materialism" that repels him as something pernicious. The last words of the sermon are these: "The errors of systematic materialism may paralyze the energies and destroy the beauty of life." He has some other faith, therefore, which preserves him from the deadly influence he deprecates, and the loss of the sense of the beauty of life which he loves. It can only be a more elevating philosophy, by his concession, that can preserve to us a sense of the beauty of life; may we not say, "the beauty of holiness?" Such good fruit must be proof of the greater truth of the higher philosophy he conceives and believes, yet does not explain or advocate, but has sought to supplant. Now how only do men attain their highest sense and example of this "beauty of life?" It is by a belief in the immortal life, and by cherishing the highest ideal of perfection, which that belief ever presents to our apprehension, with an obedience to the injunction to strive to be perfect as the higher perfection; even looking to the perfection "of our Father in heaven." That cannot be the truth of life that could "paralyze the energies and destroy the beauty of life." Why then seek to build up a philosophy which condemns itself? Why seek to establish a theory at which our given sense of truth and beauty revolts? Why seek to entomb the mind in matter, and thereby lose our own soul? The useful, the beautiful, and the perfect in God's creation attest the truths thereof and that it is His. It remains ever to be a sure test, by their fruits are all things to be known.

I would now leave it, as the testimony of one who has lived longer than the allotted three score years and ten, not unobservant of men, nor unreflecting upon the question of the wherefore of our being, with a mind consciously open to the reception of every truth presented, for all that the conviction of one mind may be worth,—that the doctrine of materialism cannot be adopted as a belief of mankind, until men shall become capable of confounding things the most opposite in nature; until they can believe that light can be darkness; good be evil; right, wrong; not until men can dissever effect from its due cause; logic from reason; creation from its Creator. Not until then, will they confound mind with matter. All nature demands a broader and truer interpretation, wherein every part shall have assigned to it its just significance, and unto the whole its adequate import be ascribed. Each and all imply no less than that there is a Creator, and that the human soul has a life immortal. If the soul of man has not this significance, then, truly, Creation is without adequate motive or result for all eternity. But if we be children and heirs of God, there is a sufficient solution of the purpose of our being, and an object worthy the glory of the universe.

CORRELATIONS OF COSMICAL AND MOLECULAR FORCE.

By Pliny Earle Chase,

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(*Read before the American Philosophical Society, February 16th*, 1872.)

If it be granted

1. That all forms of terrestrial organic energy are transformed modifications of solar radiation;
2. That centrifugal and centripetal energies tend continually to equilibrium;
3. That the kinetic energy of a perfectly elastic medium under constant pressure, bears a definable ratio to its kinetic energy under constant volume;

Then the *kinetic energy of dissociated water should be, approximately, to the kinetic energy of terrestrial revolution, as the mass of the earth, is to the mass of the sun.*

And *the energy of hydrocarbons should be, approximately, to the energy of dissociated water, as elastic energy under constant volume, is to elastic energy under constant pressure.*

For the measures, of the energy of gaseous combustion, and of the energy of orbital revolution, are, respectively, the mean height of oscillation excited by the igneous energy of the combustible compound, and the mean distance from the sun at which the earth is sustained in its orbital revolution. It is evident, from the well known laws of elasticity, that if a perfectly elastic body were lifted, *in vacuo*, to any given height, and then let fall, it would rebound to the height from which it fell, and this oscillation would be perpetual, unless disturbed by extraneous forces, in the same way, and for a similar reason, that the earth continues its elliptical oscillation about the sun. Inasmuch as the total radiating force is considered in each instance, [the time consumed in storing up and in liberating the accumulated solar energy being left entirely out of question,] the element of velocity is not involved in the preliminary determination. It may, however, be subsequently ascertained, if desired, by the formula, $v = \sqrt{2gh}$.

It is evident that the dissociated oxygen and hydrogen tend to expand, in consequence of any liberated interior energy, under constant exterior pressure, while the hydrocarbons are restrained by the cohesive forces which tend to maintain a constant volume.

For the purpose of testing the accordance, both of the postulates and of the conclusions, with the facts of observation and experiment, it might be deemed sufficient to confine attention exclusively to the lightest and most elastic gas, and to the lightest and most volatile liquid. But I believe the same principles, with simple modifications, are applicable to all forms of matter, and I have already extended the investigation, with some encouraging results, to inorganic elements and compounds. I subjoin, from Muspratt's Chemistry, all the elements and products involved

in the unstable equilibria of organic life, for which I have been able to find any recorded experimental value. In all cases which have been tested by more than one observer, the kinetic ratios represent the mean of all the latest and most authentic results. For convenience of expression, I employ the following symbols:

d—length of terrestrial day.

y'—duration of orbital revolution of the earth.

y''— " " " " the moon.

y'''— " " " " a hypothetical satellite at the surface of the earth.

g—32.0874377 feet.

r—radius of the earth—20,923,654 feet.

c', c''.... c_{xvi} = combustible (hydrogen, ether,....carbon).

$\gamma_x(\gamma'\gamma''\cdots\gamma_{xvi})$—product of combustion.

t_x (t', t''....t_{xvi})—thermal units, or number of pounds of water heated 1° C. by the combustion of 1 pound of c_x

J—Joule's equivalent, $\frac{193}{1320}$ mile—pounds.

w_x—weight of $\gamma_x \div$ weight of c_x.

γ_l'—mean height at which the earth is suspended under the centrifugal force of the sun.

γ_l''— " " " moon " " centrifugal force of the earth.

h_x—mean height at which γ_x would be suspended, in the oscillation maintained by combustion and gravitation—$J \times t_x \div 2w_x$.

$\gamma_l' \div h_x = \mu_x$, approximation to solar mass in units of earth's mass, furnished by c_x.

k_x—kinetic ratio of $c_x = \mu''_x \div \mu'$

ρ_x—ratio of experimental to theoretical value of k_x.

m', m'', m'''—mass of sun, earth, moon.

	c_x	Symbol.	γx	k_x	ρ_x	Authorities *
1	Hydrogen	H	HO	1.000	1.000	D, H, G, F&S, A
2	Ether	C_4H_5O	$4CO_2,5HO$	1.494	1.004	D., F&S.
3	Olive Oil	$C_{10}H_8O$	$10CO_2,8HO$	1.495	1.004	D.
4	Terebene	$C_{10}H_8$	$10CO_2,8HO$	1.503	1.010	F&S.
5	Marsh Gas	CH_2	$CO_2,2HO$	1.518	1.020	D., G., A., F&S.
6	Amylic Ether	$C_{10}H_{11}O$	$10CO_2,11HO$	1.521	1.022	F&S.
7	Phosphorus	P	PO_5	1.529	1.027	A.
8	Olefiant Gas	CH	CO_2,HO	1.534	1.030	D., G., F&S., A.
9	Oil of Turpentine	C_5H_4	$5CO_2,4HO$	1.542	1.036	G., F&S.
10	Oil of Lemons	$C_{10}H_8$	$10CO_2,8HO$	1.545	1.038	F&S.
11	Fusel Oil	$C_{10}H_{12}O_2$	$10CO_2,12HO$	1.596	1.072	F&S.

* A., Andrews. D., Dulong. F&S., Favre and Silbermann. G., Grassi. H., Hess. I reject Dalton's determinations of k_x for camphor (2.808), because in nearly every instance he obtained much higher values than any later experimenters. Further experiments with that substance ($C_{10}H_8O$, yielding $10CO_2,8HO$) would be interesting, and perhaps suggestive.

12 Alcohol	$C_4H_6O_2$	$4CO_2,6HO$	1.601	1.076	D., G., F&S., A.
13 Cyanogen	C_2N	$2CO_2,N$	1.647	1.106	D.
14 Acetone	C_3H_3O	$3CO_2,3HO$	1.681	1.129	F&S.
15 Wood Spirit	$C_2H_4O_2$	$2CO_2,4HO$	1.722	1.157	G., F&S.
16 Carbon	C	CO_2	1.853	1.245	D., G., H.

The following examples indicate the manner in which the several values are determined :

$$h'=J\times t'\div 2w'=\frac{193}{1320}\times\frac{34533}{2\times 9}=280.5 \text{ miles.}^*$$

$$h_{xi}=J\times t_{xi}\div 2w_{xi}=\frac{193}{1320}\times\frac{8959\times 11}{2\times 41}=175.7 \text{ "}$$

$$k_{xi}=h_{xi}\div h_1=1.596$$

If an elastic fluid is lifted above the earth's surface, subject to the (nearly) constant pressure of gravity, the superficial pressure varies as $\left(\frac{r+h}{r}\right)^2$, and the volume as $\left(\frac{r+h}{r}\right)^3$. The value of h for HO being, as we have seen, 561 miles (or twice h_1, which represents the *mean* height of oscillation), if we call r (earth's mean radius) 3956 miles, $\left(\frac{r+h}{r}\right)^3=1.4886$. This corresponds approximately to the experimental valuation adopted by Tyndall (1.421), and is almost identical with the experimental kinetic ratio of ether (1.494).

$y'''=2\pi\sqrt{r\div g}=5074$ seconds.

$y''=27$ dys, 7 h., 43 min. 12 s.

$\eta''=(y''\div y')^{\frac{2}{3}}\times r=237937$ miles.

By my hypothesis,

$$h' : \eta' :: m'' : m' \quad \therefore m'=m''\frac{\eta'}{h'}$$

And, according to well known mechanical laws,

$$m'=m''\left(\frac{\eta'}{r}\right)^3+\left(\frac{y'''}{y'}\right)^2$$

Solving the equations, we obtain the following values :

Sun's mass 330,260

" distance 92,639,500 miles.

* If s represents the extreme excursion of the exploded gases, the centre of gyration, considering the earth's surface as the axis, being $\frac{2s}{3}$, the secondary centre of oscillation, on the return towards the centre $\frac{s}{2}$, is at $\frac{5s}{9}$, and $\frac{5}{9}$ of 3453° C.=3453° F.

THE HERSCHELL-STEPHENSON POSTULATE.

By Pliny Earle Chase.

(*Read before the American Philosophical Society, March 1st*, 1872.)

Of the three postulates which I submitted to the Society at its last meeting, I presume the first will generally be considered the most questionable. The hypothesis of Herschel and Stephenson, that the coal consumed under our boilers merely imparts, to the steam, solar energies which have been imprisoned for ages by the molecular attraction of the carbon particles, has been commonly accepted as a beautiful poetical fancy, having, perhaps, some indefinite foundation in truth. Few persons, however, can have indulged the expectation that so vague a surmise would ever yield any satisfactory numerical results, and it will not be strange if even the close coincidences to which it has led me, may be regarded by many as merely accidental.

The following comparisons show the character of the agreement between estimates of solar distance, mass, and parallax, based upon various chemical and astronomical observations:

I. By Flame Analysis.

According to Experiments of	Distance.	Mass.	Parallax.
			"
Andrews	93,631,000	340,950	8.73
Favre and Silbermann	92,471,000	338,430	8.839
Grassi	92,466,000	328,370	8.84
Dulong	92,363,000	327,290	8.85
Hess	92,298,000	326,590	8.856

II. By Astronomical Computation.

According to Calculations of	Distance.	Mass.	Parallax.
			"
Encke	95,311,000	359,630	8.576
Liais	93,309,000	337,440	8.76
Newcomb	92,380,000	327,480	8.848
"	92,152,000	325,040	8.87
Stone, corrected	91,945,000	322,900	8.89
Hansen	91,672,000	319,990	8.9165
Stone	91,512,000	318,320	8.932
Leverrier	91,329,000	316,470	8.95
Wineke	91,186,000	314,930	8.964

My own faith in the significance of such coincidences, and in their suggestive value as indications of an instructive, intelligent as well as intelligible, purpose in nature, inclines me to the acceptance of speculations, based on thermodynamic, spectroscopic, and analogous theories, even before all their premises have been recognized as either axiomatic or rigidly demonstrable. The desirableness, however, of completing the

proof as soon as possible, must be admitted, and I now submit some further considerations, which, in my own judgment, impart a more strictly mathematical character to my fundamental postulate.

It is well known that the velocity acquired in falling towards an attractive centre, depends upon the attracting mass and the distance fallen through. In other words,

$$v \propto \sqrt{2gh} \propto \sqrt{\frac{2mh}{d^2}} \propto \frac{2h}{d}\sqrt{\frac{m}{2h}}$$

It is moreover evident that in any perfectly elastic particle, oscillating perpetually in a compound orbit, about two centres of attraction, as in the hypothetical case of water vapor, set in motion by the force of chemical combination, if

$$m \propto 2h,$$

the proportionate velocity communicated by gravity varying as $\sqrt{\frac{2h}{d}}$, the proportionate living force will vary as $\frac{2h}{d}$. The mean amounts of living force imparted by each of the two attracting centres will then tend constantly to equality, thus counteracting any indefinite expansion or contraction towards the centre of prepondering attraction, which would otherwise gradually draw the oscillating body to itself. This exigency can be satisfied, and a perpetual oscillation maintained by the conjoint action of gravity and elasticity, only when $2h$ has the proportional value here indicated.

The question may be approached in another way. The sustaining *vis viva* of the earth in its orbit, having been acquired by a virtual fall through the half-radius $\left(h' = \frac{d'}{2}\right)$, let it be required to find the proportionate part of the possible fall which will sustain the elastic oscillation.

Since the attracting forces (or the virtual masses acting at the point of disturbance), vary as $\frac{m}{d^2}$, the virtual centrifugal forces will vary as $\frac{m}{d}$. Then

$$2h'' : d'' :: \frac{m''}{d''} : \frac{m'}{d'} :: m'' \; d' : m' \; d''$$

$$\therefore 2h'' \propto \frac{m''d'}{m'}; \; \frac{m''}{2h''} \propto \frac{m'}{d'}; \; m \propto 2h \propto d.$$

At whatever distance from the centre the elastic particle encounters an obstacle, a portion of the force must be communicated to the obstacle, originating new molecular motions, which, if they could all be known, would show that the aggregate amount of force is still maintained. The following attempt to trace a portion of the transmitted forces of inter-

rupted oscillations, may perhaps suggest others that will be more complete and satisfactory :

Let $\frac{m'}{m''} = \frac{\text{sun's mass}}{\text{earth's mass}} = 314{,}000$*

$d' = 91{,}328{,}000$

$d'' = 3{,}962.8$

$h'' = \frac{m''d'}{m'} = 290.85$

v' = hourly velocity of a body revolving at the distance d' from the sun's centre, or at the distance h'' from the earth's centre, = 65,062.4 miles.

In consequence of the solidity of the earth, the hypothetical perpetual oscillation of the combined H and O through the major axis $2h''$, must be maintained at d'' instead of at h'' from the earth's centre. Its maximum velocity is therefore only $\frac{2h''}{d''}$ of v', which =9609.36 miles =9.24× the equatorial superficial velocity of rotation, or 9.0165× the velocity at the centre of oscillation of the semi-axis h.

The reaction of the elastic atmospheric particles, in their continual rebounds from the earth's surface, under tidal, thermal, chemical, and molecular influences, should contribute, in connection with the motion of revolution, to a rotary motion in the earth itself. The following coincidences, at the boundary lines of the interior (Telluric) and exterior (Jovian) planetary systems, seem to render it probable that a reference to centres of oscillation may ultimately account for the masses, order of arrangement, and times of rotation, of the several planets and satellites, as well as for their period of revolution.

If we assume, in the sun, as well as in the oscillating H_2O, a virtual centre of oscillation at the distance $\frac{r}{9}$ from the diametrical centre, the oscillating centre will move about a sphere, which has a volume, proportioned to that of the solar sphere, as 1 to 9^3.

If all the asteroids, satellites, comets, meteors, and undiscovered planets in our system constitute an aggregate equivalent to the mass of Uranus, the mass of the sun is 729 ($=9^3$) × the planetary mass. (*a.*)

$729 \times \frac{1}{9}$ ($=9^2$) solar radii = distance of Mercury. (*b.*)

729×1 ($=9^3$) " " = distance of farthest asteroid. (*c.*)

729×9 ($=9^4$) " " = distance of Neptune. (*d.*)

	Theoretical.	Observed.	Theoretical Error.
a	.0013717	.0013584	+.009
b	34,430,000	35,353,000	—.027
c	309,870,000	312,388,000	—.008
d	2,788,833,000	2,743,216,000	+.017

* The values are taken from Norton's Astronomy.

FURTHER APPROXIMATIONS TO THE SUN'S DISTANCE.

By Pliny Earle Chase.

(*Read before the American Philosophical Society, April 5th*, 1872.)

If it be true, as is commonly and very plausibly supposed, that molecular and cosmical laws have many significant analogies which are yet undiscovered, it may be well to seek for such analogies wherever we may reasonably hope to find them.

The height of oscillation which I have assumed as the measure of the igneous energy of combustibles, is less, and the resulting estimate of solar mass and distance is greater, if the combustible is dense, composite, or of small specific heat, than if it is rare, simple, or of great specific heat. It seems likely that even hydrogen, the most volatile of all known substances, may have undergone some condensation and loss of specific heat, and that, therefore, my first estimates by flame analysis* were all slightly in excess. This opinion is the more probable, from the fact that the mean of the most recent astronomical estimates of solar distance, is nearly one per cent. less than the mean of the flame estimates.

In searching for some clue to the coëfficient of condensation in hydrogen, if we accept the hypothesis that the luminiferous æther is a perfectly elastic material medium, we may, perhaps, be able to detect some important relations between the velocity of luminous or thermal undulations, and the velocity of oscillations which are directly traceable to gravitating action. In the primary radiation and subsequent double concentration of exploding hydrogen, there is not only a joint attraction of the gaseous particles for each other and of the whole for the earth, but there is also a generation of luminous vibrations, with a velocity such as would be produced by a gravitating force $g = \frac{v^2}{h}$. Equivalent velocities may be generated by masses of different magnitudes, provided the motion is orbital with radii varying as the masses, or the fall is virtually continued to the centre from heights equivalent to twice those proportionate radii. With these preliminary considerations I invite attention to the following coincidences:

1. At the centre of oscillation of the extreme excursion of exploding H_2O before its fall towards the centre of condensation, ($\frac{2}{3}$ of 1009.877 miles from the commencement of the fall, or $\frac{1}{3}\times 1009.877 - 336.626$ miles above the earth's surface,) the velocity imparted by terrestrial gravity in one year $\left(\frac{32.0894377\times 31558150}{5280} \div \left(\frac{3962.818+336.626}{3962.818}\right)^{\frac{1}{2}} = 184{,}130 \text{ miles}\right)$ would be closely coincident with the velocity of light. If the coincidence is exact, γ' (the Sun's distance) is $497.827\times 184{,}130 = 91{,}665{,}370$ miles. The value of h corresponding to this distance $\frac{2gt^2r^2}{4\pi^2\gamma'^2} = 573.099$ miles, which is 1.0215 times the experimental h (561.043 m).

* Ante, p. 395.

2. In consequence of the equality of velocities at η' and $h_{\odot}$, t (the time of revolution) $\propto h$. If the mass $(\oplus \div \mathbb{D}) = 81$, $(\frac{82}{81})^{\frac{3}{2}} \times 561.043 = 571.436$. In other words, *the actual* : *the experimental* value of h : : the virtual time of revolution of the Earth's centre, relatively to the Moon : the virtual time of revolution of the centre of gravity of the Earth and Moon. If this proportionality is exact, the value of η' is $\frac{tr}{\pi}\sqrt{\frac{g}{2h}} = 91{,}798{,}500$ miles.

3. The greatest distance of the Moon from the Earth is about $63r$, and $\frac{h}{h+r}$ is nearly equivalent to $\sqrt{\frac{1}{63}}$ If this equation is exact $h = 571.25$; $\eta' = 91{,}813{,}400$.

4. The velocity acquired by falling through h, from the distance $r+h$, is nearly a mean proportional between the velocities of terrestrial rotation and revolution. If $h = 569.363$, $\eta' = 91{,}965{,}500$ and the hourly velocity of revolution is $2 \times 3.14135 \times 91{,}965{,}500 \div 8766.153 = 65{,}911.7$; $3600 \times \sqrt{2gh} \div \frac{h+r}{r} = 8{,}280.6$, which is a mean proportional between 65,911.7 and 1,040.3. I can find no indication, in any of the planets or satellites, of a greater rotation-velocity than is thus indicated, and as it is difficult to conceive the possibility of such a velocity, I am inclined to regard this as the upper limit of possible value for η', and to believe, therefore, that the Sun's mean distance cannot be greater than 91,965,500 miles.

5. If we take h' a third proportional to r and h $\left(h' = \frac{h^2}{r}\right)$, the *vis viva* of rotation of an elastic particle at the Earth's surface : the *vis viva* at h' : : the force of gravity at h' : the force of gravity at the Earth's surface : : the velocity of light : the velocity which would be communicated by superficial gravity in one sidereal year.

$$497.827gt \div \left(\frac{r+h'}{r}\right)^2 = \eta' = \frac{tr}{\pi}\sqrt{\frac{g}{2h}};$$

$$\therefore\ 497.827\pi \times r\sqrt{2g} = \frac{(r+h')^2}{\sqrt{h}}.$$

If $h = 573.967$, $\frac{r}{h} = 6.90425$; $h' = 83.1323$; $\frac{(r+h')^2}{\sqrt{h}} = 683{,}279.4$;

$$\eta' = 91{,}595{,}960.$$

We thus obtain five independent determinations, each of which is based upon considerations, some of which are necessary resultants of known mechanical laws, while others are expressive of actual circumstances of equilibrium, the greatest difference between any two of the results being less than one-half of one per cent. The experimental determination from the combustion of hydrogen (1), which differs less than one-hundredth of

one per cent. from Hansen's estimate, and only one twenty-fifth of one per cent. from the mean of all the estimates, may, perhaps, be reasonably regarded as entitled to the greatest weight. The narrow compass within which they are all embraced, and the close approximation to the mean of the best astronomical computations, may be seen in the following table:

Newcomb (mean of two estimates)	92,266,000
TERRESTRIAL ROTATION (upper limit)	**91,965,500**
LUNAR DISTANCE	**91,813,400**
LUNAR MONTH	**91,798,500**
MEAN OF MECHANICAL ESTIMATES	**91,767,736**
Stone (mean of two estimates)	91,728,500
Hansen	91,672,000
HYDROGEN EXPLOSION (1)	**91,665,320**
Mean of Astronomical Estimates	91,636,300
VELOCITY OF LIGHT	**91,595,960**
Leverrier	91,329,000
Winnecke	91,186,000

Is it possible that there can be anything deceptive in these figures,—that any bias of unsuspected prejudice may have blinded me, or that I have been misled by mere fortuitous resemblances? The question whether there is not some conception of force which will unify centrifugal and centripetal, luminous, thermal, and gravitating action, is continually recurring; the accordance of Faraday's "lines of force" with lines of perfect fluidity, and the fundamental equation of oscillation, favor an affirmative answer; the increasing popularity of the theory that matter is nothing but force, prepares the way for every conceivable approximation and identification of molar and molecular laws.

If the undulations of light have any influence upon the gravity of bodies, the velocity of light being nearly uniform, its influence should tend to communicate a velocity as nearly like its own as gravity and inertia will allow, a tendency which is presumably most manifest in the most tenuous forms of matter. The gravitating velocity,

$\frac{r}{r+h}\sqrt{2gh} \propto \frac{1}{r+h}\sqrt{2mh}$, being a maximum when $r_\circ = h$ and $h \propto m$,

it does not seem unreasonable to look for analogies between the extreme excursions of planets, satellites and gases, or between times, velocities, and living forces, in the direction of that maximum.

GENERAL RELATION OF AURORAS TO RAINFALL.

By Pliny Earle Chase.

(*Read before the American Philosophical Society, April 5th*, 1872.)

In order to ascertain if the parallelism, which I have pointed out between the daily rainfall and the frequency of auroras, can be traced in the annual curves, I have constructed the following table of normals, from data furnished by Lovering's Catalogue of Auroras, and Loomis's Meteor-

ology. The tendency to increase of auroras in clearing weather, and diminution in falling weather, is shown in the Auroral and Pluvial General Means:

	Auroras.				Rainfall.			
	New England.	Western Hemisphere.	Eastern Hemisphere.	General Mean.	Lat. 5° 44′ to 35° 41′	Lat. 36° 9′ to 42° 20′	Lat. 42° 21′ to 57° 31′	General Mean.
Jan.	89	96	107	97	78	97	116	97
Feb.	100	107	125	111	75	95	103	91
March,	112	112	136	120	75	100	93	89
April,	107	103	116	109	83	106	89	93
May,	90	86	73	83	105	107	87	100
June,	84	77	42	68	129	106	84	106
July,	92	85	45	74	141	103	84	109
Aug.	109	103	79	97	138	97	89	108
Sept.	120	118	119	119	119	92	101	104
Oct.	118	117	133	123	96	94	113	101
Nov.	96	103	120	106	82	102	120	101
Dec.	81	93	105	93	80	103	122	102

INFLUENCE OF METEORIC SHOWERS ON AURORAS.

By Prof. Pliny Earle Chase.

(*Read before the American Philosophical Society, May 16th*, 1872.)

Professor Lovering's discussion of the periodicity of the Aurora Borealis (Trans. A. A. S. Vol. X., Part I.), not only exhibits maxima and minima of frequency at periods corresponding to general minima and maxima of rainfall (see above), but it also furnishes evidence of a tendency, in other great atmospheric disturbances, to increase auroral displays.

In preparing the following table, I first took the second means of Lovering's Table LII. (containing 10316 auroras, arranged according to their frequency on each day of the year). After grouping the results in five-day periods, I calculated the ratio of each ordinate to a mean ordinate of 100. Against each ordinate which corresponds to a supposed meteoric period, I set the initial K. (Kirkwood's "Meteoric Astronomy"), or W. (Wolf, cited by Lovering, p. 221).

COMPARATIVE TABLE OF AURORAL AND METEORIC DISPLAYS.

Jan.	3,	110 K., W.	Mar.	19,	144	June	2,	44	Aug.	16,	76
	8,	110 W.		24,	138		7,	44 W.		21,	88
	13,	114		29,	138 W.		12,	41		26,	95
	18,	113	Apl.	3,	133		17,	35		31,	102
	23,	110		8,	130 W.		22,	31	Sep.	5,	112
	28,	111		13,	131		27,	36		10,	123 W.
Feb.	2,	113 W.		18,	118 K., W,	July	2,	40		15,	131 W.
	7,	116 W.		23,	94 K.		7,	46		20,	138
	12,	125		28,	79		12,	44		25,	142
	17,	133 K., W.	May	3,	76		17,	40 W.		30,	139 W.
	22,	134		8,	66		22,	39 K.	Oct.	5,	133 W.
	27,	132 W.		13,	61		27,	45 K., W.		10,	129
Mar.	4,	129		18,	57	Aug.	1,	49 K., W.		15,	129 K,
	9,	133		23,	51		6,	51 K., W.		20,	133 K.
	14,	145		28,	47		11,	60 K., W		25,	132

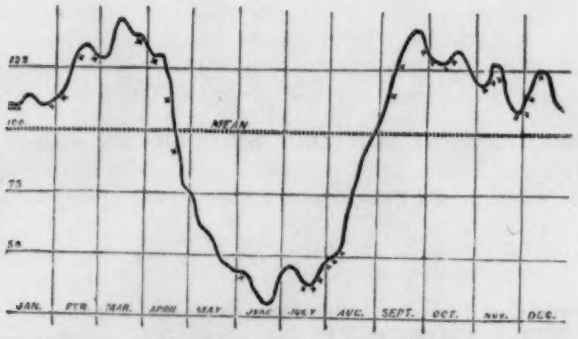
Oct.	30,	126									
Nov.	4,	120									
	9,	121 W.									
	14,	129 K., W.									
	19,	127 W.									
	24,	113									
	29,	109 K., W.									
Dec.	4,	115 W.									
	9,	122 K., W.									
	14,	127 K., W.									
	19,	125									
	24,	114									
	29,	111									

The table, as well as the accompanying curve, exhibits the following peculiarities:

1. The principal maxima occur near the equinoxes, and are apparently due to the favorable position of the earth for the development of circulating electric currents.

2. There is an evident grouping of meteoric displays in the vicinity of the maxima and minima.

3. The grouping is more strongly marked upon the ascending, than on the descending sides of the inflections.



4. The principal secondary maxima (in February, October, November and December), exhibit the most striking accordance.

5. Nearly all of the apparent exceptions to this general accordance are occasioned by the rapid decline of the general curve, which is so great as to veil the subordinate maxima, when five-day means are taken.

Of all the meteoric ordinates suggested by Kirkwood, including those which he regards as doubtful, three correspond with auroral minima, eight with increasing auroral displays, two with maxima, and only two with ordinates of diminishing auroral frequency. The two exceptional

ordinates become normal if we examine the daily curve of second means, which shows subordinate maxima on April 19th and April 24th.

Of the meteoric ordinates suggested by Wolf, four correspond with minima, nine with ascents, seven with maxima. and six with descents in the auroral curve. Of the six apparently abnormal ordinates, only two, those of March 31st and Nov. 19th, are on descending inflections of the auroral daily curve of second means.

There seems, therefore, good reason to look for an increase of auroral displays, soon after every meteoric shower.

PLANETARY ILLUSTRATIONS OF EXPLOSIVE OSCILLATION.

By Pliny Earle Chase.

(*Read before the American Philosophical Society, May 16th*, 1872.)

The secondary centre of gyration in an exploded gas, on its return towards the centre of gaseous mass, being, as I have shown, at $-\frac{5h}{9}$ (h representing the extreme excursion consequent on the explosion), we may reasonably expect, by referring the planetary masses to similar primary and secondary centres, to obtain evidence relative to the probability of the hypothesis of molar and molecular correlations. Whether the nebular hypothesis be true or false, the planets are oscillating under the combined action of centrifugal and centripetal forces. In their continual virtual fall towards the Sun, they are subject to such disturbances as arise from their mutual interaction, and should, therefore, tend to arrange themselves somewhat like the particles of an exploded gas. I submit the following exemplifications of such a tendency, the calculations being generally based upon the hypothesis that the planets are either in conjunction, or nebulously diffused along the entire line of their orbits.

1. Mercury is near the theoretical mean excursion $\left(\frac{5h}{9}\right)$ of the centre of gravity of the intra-asteroidal belt of planets.

Mercury*	$3\frac{1}{3}\times$	.3871 =	1.2903
Venus	$25\times$	.7233 =	18.0832
Earth	$31.85\times$	1. =	31.85
Mars	$3\frac{1}{3}\times$	1.5237 =	5.079
	$63.52\times$	.8864 =	56.3025

$\frac{5}{9}\times.8864=.4924$ from the centre of gravity, or .3940 from the Sun, the true distance being .3871 ; $\frac{3.8}{3.8}\frac{4}{7}\frac{0}{1}=1.0178$.

2. The actual eccentricity of Mercury's orbit : the theoretical eccentricity if the oscillation were referred primarily to the intra-asteroidal

* The values of the astronomical elements are taken from Norton's Astronomy, unless otherwise stated.

centre of gravity, nearly :: the actual : the theoretical mean excursion from that centre of gravity.

Theoretical eccentricity, $2\times(\frac{5}{9}-\frac{4}{9})=\frac{2}{9}$; $.205515\div\frac{2}{9}=.92482$.

$(.8864-.3871)\div\frac{5}{9}=.89874$; $\frac{2}{9}\frac{2}{8}\frac{4}{8}\frac{8}{4}=1.029$.

3. Neptune is near the theoretical explosive centre of the centre of gravity of the three exterior planets.

$$[2847.4\times9.539+416.7\times19.182639+532.5\times30.037]\div$$
$$[2847.4+416.7+532.5]=13.472;\ 13.472\div(1-\tfrac{5}{9})=30.312;$$
$$30.312\div30.037=1.009$$

4. Neptune's orbital centre of oscillation is near the orbit of Uranus.

$\frac{3}{5}$ of $30.03697=20.02465$; $\dfrac{20.02465}{19.182639}=1.0439$.

5. The orbital centre of oscillation for Uranus, is near the centre of gravity of the three exterior planets. The mean orbital radius of Uranus is about twice that of Saturn.

$$13.472 \text{ (See No. 3)} \div(\tfrac{2}{3}\times19.182639)=1.05345.$$

6. The theoretical mean excursion for an explosion from the Sun to Uranus, is near the centre of gravity of Uranus and Saturn.

$\frac{5}{9}$ of $19.18264=10.657$; $(2847.4\times9.539+416.7\times19.18264)\div(2847.4+416.7)=$
10.7697; $10.7697\div10.657=1.0106$.

7. The theoretical mean excursion for an explosion from the Sun to Saturn, is near the orbit of Jupiter.

$\frac{5}{9}$ of $9.539=5.299$; $5.299\div5.203=1.018$.

8. The centre of gravity of Jupiter and Saturn is near Saturn's orbital centre of gyration.

$$(\tfrac{2}{3}\times9.538852)\div\left(\frac{2847.4}{12154.4}\times4.33605+5.2028\right)=1.0226.$$

9. The theoretical mean excursion from Jupiter to the Sun, is near the inner limit of the asteroidal belt.

$(1-\frac{5}{9})\times5.2028=2.31236$; $2.31236\div2.2014=1.05$.

10. The centre of gyration of Jupiter's orbital radius is near the exterior limit of the asteroidal belt.

$\frac{3}{5}$ of $5.2028=3.4686$; $3.4686\div3.4205=1.01406$.

11. If all the known primary planets were aggregated at Jupiter's orbital centre of gyration, the centre of gravity of the solar system would be near the Sun's surface.

$3.4686\times214.86=745.248$; $759.46\div745.284=1.01908$.

12. The centre of oscillation for the exterior asteroid, is near the orbit of the inner asteroid.

$\frac{3}{4}$ of $3.4205=2.2803$; $2.2803\div2.2014=1.03584$.

13. The centre of oscillation for the theoretical inner asteroid, is near the orbit of Mars.

$\frac{3}{5}$ of $2.2803=1.5202$; $1.523691\div1.5202=1.0023$.

14. The centre of oscillation from Mars to the Sun is near the orbit of the Earth.

$\frac{3}{5}$ of $1.5237=1.0158$.

15. The theoretical mean excursion from Mars to the Sun, is near the orbital centre of oscillation for the Earth.

$$(1-\tfrac{5}{6})\times 1.5237=.6772\,;\ .6772\div .6667=1.01575.$$

16. The theoretical mean excursion from the Sun to the Earth is nearly midway between the orbits of Mercury and Venus.

$$(.3871+.7233)\div 2=.5552\,;\ \tfrac{5}{9}\div .5552=1.0006.$$

17. The theoretical mean excursion from Mars to the Sun, is near the centre of gravity of Venus and Mercury.

$$(3\tfrac{1}{3}\times .3871+25\times .7233)\div(3\tfrac{1}{3}+25)=.6838\,;\ .6838\div .6772 \text{ (See No. 15)}=1.01.$$

18. The theoretical mean excursion from the Earth to the Sun, is near the extreme excursion or aphelion of Mercury.

$$.4666\div(1-\tfrac{2}{9})=1.05.$$

19. The theoretical mean excursion from Venus to the Sun is nea Mercury's perihelion.

$$(1-\tfrac{5}{6})\times .72333=.32148\,;\ .32148\div .3075=1.04542.$$

20. The theoretical mean excursion from Mercury to the Sun is near the limit of the Sun's possible atmosphere (the limit at which the equatorial centrifugal force is equal to gravity).

$$[(1-\tfrac{5}{6})\times .3871]^{\frac{3}{2}}\times 365.2564=26.065\,;^{*}\ 26.065\div 25.187=1.035.$$

21. If the several planets were aggregated precisely, as they are approximately, at direct or reverse centres of oscillation, the centre of inertia of the entire planetary system ($\sqrt{\Sigma mr^2\div\Sigma m}$) would be near the orbit of Saturn.

$$(3\tfrac{1}{3}\times 1^2+25\times 2^2+31.85\times 3^2+3\tfrac{1}{3}\times 4^2+9307\times 18^2+2847.4\times 27^2+416.7\times 54^2+532.5\times 81^2)\div(3\tfrac{1}{3}+25+31.85+3\tfrac{1}{3}+9307+2847.4+416.7+532.5)=27.28^2\,;\ 27.28\div 27=1.0104.$$

22. Notwithstanding the variations from centres of oscillation, consequent upon mutual planetary interactions, the centre of planetary inertia is still near the orbit of Saturn.

$$\Sigma mr^2(1,150,671,134)\div\Sigma m(13167.12)=9.348^2\,;\ 9.5389\div 9.348=1.0204.$$

23. The distance of the Moon's orbital centre of oscillation from the centre of the Earth, is very nearly a mean proportional between the limit of the Earth's possible atmosphere and the Moon's orbital radius.

$$(\tfrac{1}{9})^2 \text{ of } 238{,}800=26{,}533\,;\ (24\div 1.40937)^{\frac{3}{2}}\times 3962.818=26{,}230\,;\ 26{,}533\div 26{,}230=1.01155.$$

24. The *vis viva* of revolution at the Earth's surface : the equatorial *vis viva* of rotation, nearly : : Earth's orbital radius : twice Moon's radius of orbital gyration.

$$(17{,}066\div 1040.3)^2\div(91{,}328{,}000\div\frac{4\times 238{,}800}{3})=1.00545$$

* The approximate coincidence of this period with Hornstein's magnetic cycle (26½ days. *Vienna Academy*, June 15, 1871) is noteworthy.

SOLAR AND PLANETARY ROTATION.

By Pliny Earle Chase.

(*Read before the American Philosophical Society, May 16th*, 1872.)

The similarity in the length of day, between the principal and subordinate planets, both in the intra and the extra-asteroidal belt, is so obvious, that many attempts, of which Kirkwood's is the most satisfactory, have been made to formulate it.

I have long thought that there is some simple explanation for the rotation, as well as for the revolution of the heavenly bodies. My recent investigations of explosive gyration, have yielded some interesting results, which, from their relation to the most important bodies of our system, encourage me to hope for further and more minute developments of a like kind.

1. The sidereal revolution of the Moon : the sidereal rotation of the Earth, nearly :: the equatorial value of g at the Sun : the equatorial value of g at the Earth.

$$27.3669 \div 27.292 = 1.00275.$$

2. The action of terrestrial superficial gravity against a uniform opposing force for a sidereal half-day, would be sufficient to give a velocity equivalent to that of a planet near the Sun's surface.

$43{,}082g = 261.8164$ miles; $265.5184 \div 261.8164 = 1.01414$, which is nearly equal to 1 + the Earth's orbital eccentricity.

3. The action of the superficial gravity of Jupiter for a sidereal half-rotation, would also be sufficient to give a velocity equivalent to that of a planet near the Sun's surface.

$18{,}863 \times 2.41g = 276.247$; $276.247 \div 265.5184 = 1.0406$; which is nearly equal to 1 + Jupiter's orbital eccentricity.

4. The action of solar superficial gravity for a sidereal half-rotation, would give nearly the velocity of light.

$\frac{1}{2}$ of $25.1868 \times 86{,}400g = 180{,}465$; $183{,}454 \div 180{,}465 = 1.0166$.

5. The action of terrestrial gravity, near the Earth's surface, for a sidereal year, would also give a velocity equivalent to that of light.

$31{,}558{,}150g = 191{,}792$; $191{,}792 \div 183{,}454 = 1.04545$, which is nearly equal to 1 + Jupiter's orbital eccentricity.

6. The orbital radius of Saturn : Mercury's orbital radius, nearly :: time of solar rotation : time of terrestrial rotation.

$$9.53885 \div .3871 = 24.642; \quad 25.187 \div 24.642 = 1.0221.$$

7. The distance of Neptune from the Sun, is nearly equivalent to one-fourth the orbit of Uranus.

$$\frac{19.182639\pi}{2} \div 30.037 = 1.00233.$$

8. The mass of the Sun : the mass of the Earth, nearly :: cube of Earth's orbital radius : cube of Sun's semi-circumference.

$$(214.86 \div \pi)^3 = 319{,}894; \quad 319{,}894 \div 314{,}000 = 1.01878.$$

9. The velocity of planetary revolution at the Sun's surface : velocity of solar rotation, nearly :: Earth's orbital radius : Sun's radius.

$$955{,}870 \div 4{,}421.7 = 216.173\,;\ 216.173 \div 214.86 = 1.00613.$$

10. The square of Jupiter's orbital radius : square of Earth's orbital radius, nearly :: g at Sun : g at Earth.

$$27.292 \div 5.2028^2 = 1.00824 \text{ (Compare No. 1).}$$

ÆTHEREAL DENSITY AND POLARITY.

By Pliny Earle Chase.

(*Read before the American Philosophical Society, May 16th*, 1872.)

If the conditions of equilibrium in a perfectly elastic gas have been disturbed by explosion, in the restoration of equilibrium, the particles will simultaneously rush towards each other, and towards the attractive centre m. If h is the extreme excursion consequent on the explosion, the centre of oscillation of each exploding particle being at $\frac{2h}{3}$, the centre of gyration of its return towards the centre of gaseous mass $\left(\frac{h}{2}\right)$ is at $\frac{5h}{9}$. The centre of gyration of the fall from $\frac{5h}{9}$ to the Earth, is at $\frac{5h}{27}$ above the Earth's surface, or at $r+\frac{5h}{27}$ from the Earth's centre.

If $h : r+\frac{5h}{27}$ :: the orbital *vis viva* about a diameter $\frac{5h}{9}$: the *vis viva* which would be communicated by virtual fall through $\frac{5h}{9}$ :: 1 : 4, we have $27r = 103h$; $\frac{5h}{9} = d' = 577.113$ miles; $r' = 91{,}345{,}800$ miles; $\frac{r}{d} = 6.8666$; $\frac{68666}{78666}\sqrt{2gd'} = 6103$ feet per second. The approximation of the estimated velocity of hydrogen (6050, Clausius; 6055, Joule) to this theoretical velocity, seems to indicate that the elasticity of hydrogen is nearly perfect. The inference is strengthened by the close approximation of my first estimates by flame analysis, to the mean of the best astronomical estimates of the Sun's distance.

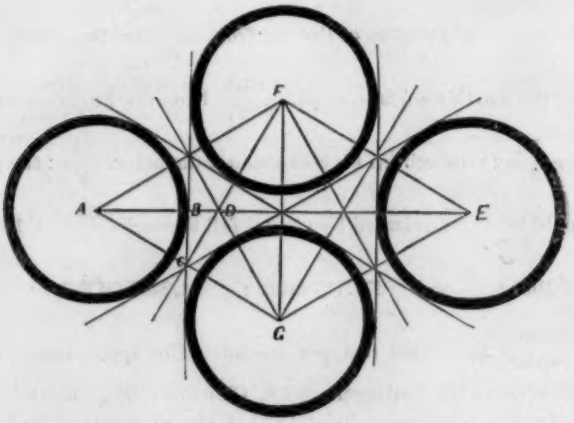
Let d'=density of luminiferous æther; d''=density of hydrogen. Calling the velocity of sound in hydrogen 4163 feet, and the velocity of light 183,454 miles, if the elasticities are the same we have the proportion,

$$d' : d'' :: 4163^2 : (183{,}454 \times 5280)^2 :: 1 : 54{,}130{,}000{,}000.$$

Upon the hypothesis that gravitation is an incidental result of æthereal

elasticity, Professor Norton has found* that "at the distance $80r$ the repulsion becomes very nearly the same for all the assumed values of $-\frac{n}{m}$;" n and m being centres of origination for the interior and exterior wave systems of the æthereal atomic envelopes. Now if r=Sun's radius, and r'=Mercury's orbital radius, r' is nearly equivalent to $80r \times (\text{sec. } 30^\circ)^{\frac{1}{3}}$. The second factor may be deduced in the following manner:

If we suppose a collection of spherical atoms of equal magnitude, each of which has condensed around it an æthereal envelope, to be arranged in the most compact manner possible, the lines joining the centres of three contiguous particles will form an equilateral triangle. If the envelope is of such density as to allow the indefinite rectilinear transmission of waves between adjacent particles, one-half the distance between the centres of two adjacent atoms, will be a mean proportional between the radius of the atom and the distance between an atomic centre and an adjacent æthereal centre; the ratio of the atomic radius to the half-distance, and of the half-distance to the inter-central distance, being each equal to the ratio of radius to sec. 30°. In the accompanying figure,



$$AB : AC :: AC : AD :: \text{rad.} : \text{sec. } 30^\circ :: 1 : \sqrt{1.25}.$$

According to the hypothesis of Mossotti, that the æthereal particles are infinitesimal in proportion to the atoms, the sphericity of the atomic surface may be disregarded, and the virtual radius of the æthereally-enveloped atom may be supposed to vary as the mass. But in atoms of

* Amer. Jour. Sci., May, 1872, p. 340.

uniform density, $r \propto m^{\frac{1}{3}}$, therefore it need not surprise us if we find in different relations of cosmical masses, the three factors, sec. 30°, $(\text{sec. } 30°)^{\frac{1}{2}}$, $(\text{sec. } 30°)^{\frac{1}{3}}$.

1. Mercury's orbital radius being, as I have said, $r' = 80r \times (\text{sec. } 30°)^{\frac{1}{3}}$. Neptune's orbital radius is $80^2 r$, or $80r' \div (\text{sec. } 30°)^{\frac{1}{3}}$.

$$[80r \times (\text{sec. } 30°)^{\frac{1}{3}}] \div (.3870987 \times 214.86r) = 1.00126.$$
$$(30.03697 \times 214.86r) \div 6400r = 1.0084.$$

2. The distance of the exterior orbital limit of the asteroidal belt (Cybele) is nearly a mean proportional between the distances of Mercury and Neptune.

$$(.3870987 \times 30.03697)^{\frac{1}{2}} \div 3.4205 = 1.003115.$$

3. If the Moon's mass is $\frac{1}{83.032}$ of the Earth's mass, her distance is analogous to that of Mercury, being $80 \times (\text{sec. } 30°)^{\frac{1}{3}} \times$ the distance of the Earth's centre, from the centre of gravity of the terrestrial-lunar system. The mean of five recent estimates of the Moon's mass, given by Denison, is $\frac{1}{83.127}$.

$$83.127 \div 83.032 = 1.001156.$$

4. The year of Mercury : Neptune's year :: the velocity of a planet near the Sun's surface : the velocity of light, or nearly :: sec. 30° × the mass of the planetary system : the mass of the Sun.

$$(60126.72 \div 87.969258) \div (183,454 \div 265.5184) = 1.01088.$$
$$(60126.72 \times \text{sec. } 30°) \div (87.969258 \times 759.46) = 1.00617.$$

5. Venus may be regarded as an exterior satellite of the Earth, at a limit analogous to that of the solar system. For $80^2 \times$ Earth's radius nearly = Venus's distance at perigee.

$$80^2 \times 3962.818 = 25,362,050\,;\ 25,362,050 \div 25,268,000 = 1.0037.$$

6. The year of Uranus divided by $(\text{sec. } 30°)^{\frac{1}{3}}$, is equivalent to the month of a terrestrial satellite near the perigee distance of Venus (omitting considerations dependent upon solar acceleration and satellite-mass).

$$(25,268,000 \div 238,800)^{\frac{3}{2}} \times 27.32166 \times (\text{sec. } 30°)^{\frac{1}{3}} \div 30,686.821 = 1.006.$$

7. The mass of the intra-asteroidal planets : the mass of all the planets, nearly :: Sun's radius $\times (\text{sec. } 30°)^{\frac{1}{3}}$: Earth's orbital radius.

$$(63.52 : 13167.12) \div [(\text{sec. } 30)^{\frac{1}{3}} : 214.86] = 1.00131.$$

My experiments in the years 1864 and 1865,* the most important of which were repeated before the Society, demonstrated that the simple mechanical action, of such elastic vibrations as are excited by the conjoint influence of solar radiation and terrestrial rotation, would not only produce polarity in a needle susceptible of similar vibrations, but it

* Proc. Amer. Philos. Soc. ix., 339; x., 151 sqq.

would also cause such daily and annual fluctuations as those of the magnetic needle. Professor Norton says* that "no conception has hitherto been formed of possible atomic movements capable of originating the electric forces, and producing even the simplest of the electrical phenomena." The dependence of the polarity of the compass upon electrical currents encourages the belief that all the "possible atomic movements capable of originating the electric forces," may be traceable to some arrangement of elastic æthereal particles like the one I have above suggested. The mutual attraction of the atoms A and E is only one-third as great as that of the atoms F and G, and under the influence of centrifugal force, the several lozenges AFEG would yield most readily in the direction EG.

THE SUN-SPOT CYCLE OF 11.07 YEARS.

By Pliny Earle Chase.

(*Read before the American Philosophical Society, May 16th*, 1872.)

The most recent and careful discussion of the observations upon the amount and frequency of Sun-spots, by De La Rue, Stewart and Loewy, † assigns to the principal cycle a duration of 11.07 years. Kirkwood (ante, vol. xi., p. 100) had previously given nearly the same estimate (11.072 years). If the spots are attributable to disturbances produced by gravitating action, the major axis of the revolving disturbing force should be $[(11.07 \div 11.862)^{\frac{2}{3}}] = .955 \times$ Jupiter's, or $4.969 \times$ the Earth's major axis. The mean radius vector of perturbation is, therefore, nearly equivalent to Jupiter's mean perihelion distance ($.95184 \mathcal{Y}$, or $4.952 \oplus$) as well as to the mean distance of the centre of gyration of the planetary sytem.

$\frac{2}{3} \times [(3\frac{1}{3} \times .3871 + 25 \times .7233 + 31.85 \times 1 + 3\frac{1}{3} \times 1.5237 + 9307 \times 5.2028 + 2847.4 \times 9.5389 + 416.7 \times 19.1826 + 532.5 \times 30.037) \div (3\frac{1}{3} + 25 + 31.85 + 3\frac{1}{3} + 9307 + 2847.4 + 416.7 + 532.5)] = 5.101$; $5.101 \div 4.969 = 1.0265$; $4.969 \div 4.952 = 1.0035$.

The theoretical mean excursion between Jupiter's perihelion and his mean distance, corresponds very nearly with the above value of the planetary centre of gyration.

$$4.952 + \tfrac{2}{3} \times (5.2028 - 4.952) = 5.091 \text{ ; } 5.101 \div 5.091 = 1.002.$$

If Jupiter's aphelion distance represents the aphelion distance of the aggregate of forces which produce the Sun-spots, the disturbance-perihelion is $(2 \times .955 - 1.048) = .862 \times \mathcal{Y}$'s, or $4.485 \times \oplus$'s radius vector. This corresponds very nearly with the linear centre of oscillation, of the mean

* Loc. cit., p. 330.

† Proc. Roy. Soc., Dec. 21, 1871; Phil. Mag., May, 1872.

action of all the planets, except Jupiter, upon the Sun's surface. According to the values adopted in Norton's Astronomy, $(1-\frac{3}{5})\times(\Sigma md \div \Sigma m$ ☿, ♀, ⊕, ♂, ♄, ♅, ♆$)=4.422$; $4.485 \div 4.422=1.015$.

The closeness of the harmony, pointed out by Kirkwood, between the Wolfian and Mercurial cycles, is very interesting. In some respects the position of Mercury is more nearly pivotal than that of either of the other planets. Its centre of explosive oscillation, relatively to the Sun, is near the limit of the Sun's possible atmosphere. $(\frac{4}{5}\times.3871)^{\frac{3}{2}} \times 365.2564 \div 25.187=1.036$. Its mean radius vector (.3871) is not much greater than the radius of the centre of oscillation (.3333) of the Earth's disturbing action upon the Sun. That centre of oscillation is, in its turn, near the centre of the counterpoising moments of inertia of the Sun and the planetary system. For $\Sigma m(d-.3333)^2 \div \Sigma m=9.0776^2$; $759.46 \div 9.0776^2 =.3294^2$; $.3333 \div .3294=1.012$. It may be well to observe that this approximation is nearly identical with the one above noted (1.015) between the virtual centre of gravity of the Jupiter-disturbing planets, and the Sun-spot disturbance-perihelion.

In order to form an estimate of the extent, to which circumstances favoring the generation or disturbance of æthereal waves affect the amount of spotted surface, I would suggest a preliminary examination of observations with especial reference to the following planetary configurations:

1. When the Sun is near the linear centre of oscillation ($\frac{3}{5}$) of two planets in heliocentric opposition: *e. g.*, near the opposition of Mercury and Venus, especially if Mercury is about 60° from perihelion; of Venus and Mars, when Mars is about 40° from perihelion; of Jupiter and Saturn, when Saturn is near aphelion; of Saturn and Uranus.

2. When one of two planets in heliocentric conjunction is near a linear centre of oscillation of the longer radius vector: *e. g.*, near the conjunction of the Earth and Mars; of Mars and Mercury, if Mars is near perihelion and Mercury near aphelion; of Jupiter and Mars, if Mars is near aphelion; of Jupiter, Saturn and Uranus, (the centre of gravity of Jupiter and Saturn being at about $\frac{3}{4}$ of the distance from Uranus to the Sun); of Saturn and Neptune, when Saturn is near aphelion; of Uranus and Neptune.

3. When one of two planets in heliocentric conjunction is near a centre of explosive oscillation ($\frac{2}{5}$): *e. g.*, near the conjunction of Mercury and Venus, if Mercury is at somewhat more than its mean distance from the Sun; of Mercury and the Earth, if Mercury is near aphelion; of Mercury, Venus, and the Earth or Mars; of Jupiter and Saturn.

ÆTHEREAL OSCILLATION, THE PRIMORDIAL MATERIAL FORCE.

By Pliny Earle Chase.

(*Read before the American Philosophical Society, July* 19, 1872.)

In any explosive or other analogous action along a given diameter, cardinal points occur at $\frac{1}{5}$ radius and $\frac{2}{5}$ radius (—the distance from

radial terminus to a centre of explosive oscillation), at $\frac{1}{3}$ and $\frac{2}{3}$ (=distance to a centre of linear oscillation), at $\frac{1}{2}$ (=distance to linear centre of gravity), and at $\frac{1}{3}$ and $\frac{2}{3}$ (=distance to a centre of reverse or direct explosive oscillation). The various possible combinations of these numbers favor phyllotactic and other systematic arrangements to such a degree, that the very wealth of planetary illustration becomes burdensome and perplexing, and the attempt to trace the development of our cosmical system to simple laws seems almost hopeless.

If the primitive disturbance is accompanied (as it must almost necessarily be), by rotation, the ratio 1 : 9 assumes special importance, inasmuch as it represents the proportionate distance of the centre of rotation from the rotating centre of explosive oscillation. Assuming r=Sun's radius, as our fundamental unit, we are at present unable to determine whether there is any permanent limit at $9r$, that point being within the sphere of solar atmospheric retardation; but I have shown in my communication of March 1, 1872, that there are important divisions,

Near 9^2r, the inner limit of the planetary system..... α

Near 9^3r, the dividing mean between the intra- and the extra-asteroidal planets..... β

Near 9^1r, the outer planetary limit..... γ

The other ratios are exemplified by the positions of

Saturn and Neptune, 1 : 3..... δ

Earth and Mars, 2 : 3..... ϵ

Saturn and Uranus, 1 : 2..... ζ

Uranus and Neptune, from Saturn, 4 : 9..... η

Uranus and Jupiter, from Neptune, 4 : 9..... θ

Jupiter and Saturn, 5 : 9..... ι

I do not find so much evidence of the marked cosmical influence of centres of linear oscillation, as I do of centres of direct and explosive oscillation. The positions $\frac{4r}{9}$ and $9\times\frac{4r}{9}$, are both within the sphere of retardation; but at $9^2\times\frac{4r}{9}=36r$, we are near the centre of explosive oscillation between Mercury and the Sun, and also near the limit of the Sun's possible atmosphere,* which is probably not less than $35.59r$ (according to Spörer's estimate of the time of solar rotation), and not greater than $37.22r$ (according to Hornstein's estimate of the $26\frac{1}{3}$ day magnetic cycle). κ

Near $9^3\times\frac{4r}{9}=324r$, we find the planet Mars..... λ

" $9^4\times\frac{4r}{9}=2916r$, is a centre of explosive oscillation between Uranus and Saturn..... μ

* The limit of equal equatorial centrifugal and centripetal force.

The ratio $\frac{9}{8}$ is the unit factor for the explosive centres of oscillation of α, β, and γ.

The combined ratios of direct and reverse centres of oscillation, $\frac{9}{8}\times\frac{8}{9}=\frac{72}{72}$, determine the following interesting positions:

Near $9\times\frac{20r}{81}=\frac{20r}{9}$, is the centre of gravity of the solar system, at heliocentric conjunction*..... ν

Near $9^2\times\frac{20r}{81}=20r$, is the centre of explosive oscillation, between the limit of solar retardation and the Sun's surface..... ξ

Near $9^3\times\frac{20r}{81}=180r$, is the centre of gravity of Mercury, Venus, and the Earth..... o

Near $9^4\times\frac{20r}{81}=1620r$, is the centre of gravity of the planetary system. π

Near $9^5\times\frac{20r}{81}=14580r$, is a point which I will designate as the *reciprocal of gravity* for the solar system..... ρ

If the centre of explosive gyration from the Sun to Neptune be taken as a unit, and a point at a distance of 9 of those units $=32805r$ be regarded as the seat of a new explosive action, the point ρ is near the centre of explosive gyration *towards the solar system*. If the centripetal is equal to the radial or centrifugal action, and if gravity is a resultant of æthereal oscillation, the square of the periodic time being 32 times as great as the square of the time of fall to an attracting centre, the modulus of light, relatively to the Sun, should be $32\times\frac{1}{2}\times32805r=466560r$..... ς

The closeness of this estimate is shown by the following calculation:

log. v^2	10.527057†
" g at Sun	1.219737
" light mod.	11.307320
" r	5.628452
" mod. $\div r$	5.678868

$\therefore$ modulus of light $=477384.6r$.

The half-modulus is the height of virtual fall required, during orbital revolution at the Sun's surface, to acquire the velocity of light, if there were no æthereal resistance. Its relation to three cardinal positions in our system, is expressed in the following proportion:

$\frac{1}{2}$ modulus : ♅'s rad. vec. :: ⊕'s rad. vec. : ⊙'s rad.

The approximate value of the Earth's radius vector, as thus determined, is $213.54r$..... τ

* Whenever I have occasion, in the present paper, to speak of the centre of gravity of two or more planets, they will be considered as in heliocentric conjunction, and at their mean distances from the Sun.

† The values of the astronomical elements are taken from Norton's Astronomy.

The same modulus-ratio is also nearly equivalent to the ratio of the aggregate extra-asteroidal, to the aggregate intra-asteroidal planetary masses..... υ

If Mercury be regarded as having its mean distance at a direct explosive centre of oscillation, its perihelion distance is at the reverse explosive centre..... φ

The combination $\frac{5}{9}\times\frac{5}{9}-\frac{4}{11}$, furnishes the following planetary positions.

Near $9^3\times\frac{25r}{81}-225r$, is the centre of gravity of the Earth and Mars. χ

Near $9^4\times\frac{25r}{81}-2025r$, is the orbit of Saturn..... ψ

The foregoing approximations are embodied in the following synopsis:

TABLE I.

Centrifugal Evidences of Planetary Explosive Oscillation.

	(A) Theoretical.	(B) Observed.	(B—A)÷A.	Basis.
α	81.	83.17	.027	9^2
β	729.	734.93	.008	9^3
γ	6561.	6453.73	—.016	9^4
δ	.3333	.3149	—.055	$\frac{1}{3}$
ϵ	.6667	.6563	—.016	$\frac{2}{3}$
ζ	.5	.4973	—.005	$\frac{1}{2}$
η	.4444	.4705	.059	$\frac{4}{9}$
θ	.4444	.4371	—.016	$\frac{4}{9}$
ι	.5556	.5454	—.018	$\frac{5}{9}$
$\varkappa$	36.	36.96	.027	$\frac{4}{9}\times9^2$
λ	324.	326.59	.008	$\frac{4}{9}\times9^3$
μ	2916.	2970.43	.019	$\frac{4}{9}\times9^4$
ν	2.2222	2.17	—.025	$\frac{4}{9}\times\frac{5}{9}\times9$
ξ	20.	20.43	.022	$\frac{4}{9}\times\frac{5}{9}\times9^2$
o	180.	182.83	.016	$\frac{4}{9}\times\frac{5}{9}\times9^3$
π	1620.	1625.69	.004	$\frac{4}{9}\times\frac{5}{9}\times9^4$
ρ	14580.	14341.64	—.016	$\frac{4}{9}\times\frac{5}{9}\times9^5$
ς	466560.	477384.6	.023	$32\times\rho$
τ	213.54	214.86	.006	ς
υ	213.54	206.29	—.034	ς
φ	.8	.7945	—.007	$\frac{4}{5}\div\frac{5}{9}$
χ	225.	225.46	.002	$\frac{5}{9}\times\frac{5}{9}\times9^3$
ψ	2025.	2049.51	.01	$\frac{5}{9}\times\frac{5}{9}\times9^4$

The importance of combining the centres of direct and reverse explosive gyration, in forming the units of the series which is to contain the modulus of equal universal action and reaction, is obvious.

Reversing our procedure, and commencing at the centre of oscillation of the reciprocal of gravity (α'), we find the following relationships:

$\frac{2}{3}\ \alpha'$ is near the mean position of Neptune.....β'
$\frac{2}{3}\ \alpha'$ " the c. grav. of Neptune and Uranus.....γ'
$\frac{2}{3}\ \gamma'$ " " " of Neptune, Uranus and Saturn.....δ'
$\frac{2}{3}\ \delta'$ " " " of the four outer planets.....ε'
$\frac{2}{3}\ \varepsilon'$ " " mean position of Jupiter.....ζ'

The centre of linear oscillation, therefore, appears to have had an important influence in determining the positions of Neptune and Jupiter, and the centre of explosive oscillation in fixing the places of the intermediate planets. Neptune's position is also near the reverse centre of explosive oscillation of the reciprocal of gravity, $\frac{2}{3}$ of $\frac{2}{3}$ being equivalent to $\frac{4}{9}$.

From the excess of the observed over the theoretical value of the modulus of light (ρ), in the foregoing table, as well as from the fact that the theoretical modulus best satisfies the hypothesis of explosive positions in the outer planetary system, I infer that the mean velocity of light between Neptune and the Sun, is retarded a little more than one per cent. by the condensation of æther towards the Sun.

$\frac{2}{3}\ \zeta'$ is near the centre of gravity of the principal asteroids, and also near the centre of explosive oscillation from Cybele to Flora.....η'
$\frac{2}{3}\ \eta'$ is near the mean position of Mars.....θ'
$\frac{2}{3}\ \theta'$ is near the centre of gravity of the three interior planets.....ι'
$\frac{2}{3}\ \iota'$ is near the linear centre of oscillation of Venus.....$\varkappa'$
$\frac{2}{3}\ \varkappa'$ is near Mercury's perihelion.....λ'
$\frac{2}{3}\ \lambda'$ is near the explosive centre of gyration, which limits solar atmospheric retardation.....μ'

This second series of coincidences is grouped in the following table:

TABLE II.

Centripetal Evidences of Explosive Oscillation.

	(A) Theoretical.	(B) Observed.	(A–B) ÷ A	Basis. $\frac{1}{4.5}$ modulus.
α'	9720			
β'	6480	6453.72	.004	$\frac{2}{3}\alpha'$
γ'	5400	5429.62	—.005	$\frac{5}{9}\alpha'$
δ'	3000	2894.57	.035	$\frac{5}{9}\gamma'$
ε'	1633.33	1632.69	.000	$\frac{5}{9}\delta'$
ζ'	1088.89	1117.87	—.027	$\frac{2}{3}\varepsilon'$
η'	604.94	588.07*	.028	$\frac{5}{9}\zeta'$
	"	589.41	.026	"
θ'	336.08	326.59	.029	$\frac{5}{9}$
ι'	186.71	182.83	.021	$\frac{5}{9}\theta'$
$\varkappa'$	103.73	103.61	.001	$\frac{5}{9}\iota'$
λ'	57.63	56.07	.027	$\frac{5}{9}\varkappa'$
μ'	32.02	32.36†	—.011	$\frac{5}{9}\lambda'$

* Mean radius vector of Juno, Ceres, and Pallas.

† $\frac{8}{9}$ of 36.4; 36.4 being the mean of the two extreme values, derived from Sporer's and Hornstein's estimates.

$$\mu' = \tfrac{5}{6} \times (\tfrac{3}{2})^9 \times r$$

$$\mu' \div r = \text{modulus of light} \div \mu = T^2 \div t^2$$

There are, therefore, NINE principal planetary orbital divisions, determined mainly by centres of explosive gyration; NINE successive centres of linear oscillation between the modulus of light and the reciprocal of gravity; NINE similar centres between the limit of the Sun's possible atmosphere and the Sun's surface; and finally, NINE successive powers of NINE, that exert important centrifugal determinations. For we find:

At $9^{-3}\,r$ the fulcrum of the solar system, if the planetary masses were concentrated in a point at r.

At $9^{-2}\,r$ is the seat of an explosive oscillation, which would tend to detach a nebulous ring, with a mass $9^{-3}\,m$, provided the centre of oscillation of the ring were at the present geometrical planetary mean, $9^{-3}\,r$. For, in order that the separation should begin, the velocity of nebular rotation at the surface of the central body should bear such proportion to the mean velocity of revolution in the ring as the radius of the central mass to the radius of the ring's centre of oscillation, and as the velocity of virtual revolution at the central surface, to the like velocity at the seat of explosion, $(1 \div 81^{\frac{3}{2}\cdot})$

At $9^{-1}\,r$, a planetary mass which was in nebulous condition in the above ase, having acquired sufficient central condensation for the detachment of an interior planet, would have its fulcrum at the Sun's surface, if its centre of gravity were at the distance of Mercury. The combined effect of these two primitive hypothetical breaks is perhaps recorded in the solar rotation, which occupies nearly, if not *precisely*, $\frac{5}{6} \times \frac{1}{3} \times 729$, $\times$ the planetary orbital time at the Sun's surface.

At $9^0\,r$ is the Sun's surface, the probable seat of many of the explotions which have lately attracted so much attention.

At NINE r, is the first theoretical exterior limit of explosion, in which she Sun is central and its opposite surfaces are centres of alternate direct and reverse explosive oscillation. Here is, perhaps, the limit of an important solar envelope.

Near NINE times the first exterior limit, or $9^2 r$, is the orbit of Mercury.

Near NINE times the second exterior limit, or $9^3 r$, is the asteroidal limit.

Near NINE times the third exterior limit, or $9^4 r$, is the orbit of Neptune.

Near NINE times the fourth exterior limit, or $9^5 r$, is the centre of Sunward explosive oscillation which determines the reciprocal of gravity.

Such considerations, conjoined with the observed increase of spotted surface on the side of the Sun next the Earth and most remote from other disturbing planets,* seem to furnish a clue to the solution of the Sun-spot mystery. Even if all the planets were so arranged as to be either in mutual heliocentric conjunction or opposition, their combined

* De La Rue, Stewart and Loewy. *Proc. Roy. Soc.*, xx., 210. *sqq.*

influence would not suffice to raise a tide of a quarter-inch at the Sun's surface. But variations of inertia ($m\,d^2$) and of power to produce local oscillations $\left(\frac{m}{d^2}\right)$ may be much more important, in their influence on fluid bodies, than differential tidal variations $\left(\frac{m}{d^3}\right)$. At the very outset of my cosmical investigations (*ante*, ix., 287), I gave a method for estimating the Sun's distance by comparing the atmospheric inertia relatively to the Earth, with the same inertia relatively to the Sun. The remarkable coincidence of the disturbing focus of the Wolfian cycle with the centre of linear oscillation in the planetary system, seems to render it probable that solar explosions and spots are also determined by laws of inertia and local oscillation.

ON BATHMODON, AN EXTINCT GENUS OF UNGULATES.

By Edward D. Cope.

(*Read before the American Philosophical Society, Feb.* 16, 1872.)

The present form embraces some of the largest Perissodactyles, or odd-toed Ungulata, of our Tertiary Strata. It is represented by remains of two species, which include portions of the cranium, with teeth and fragments of jaws; vertebræ, fragments of scapular and pelvic arches and bones of the limbs. The distal end of the tibia is wanting, but that of the fibula indicates an odd-toed animal, and the third trochanter on the exterior ridge of the femur confirms the reference.

There are probably four superior molars, though three only are preserved. Two premolars only remain of the superior species, but the fragment of ramus mandibuli, referred to the same species, exhibits four premolars; from a consideration of the sizes of the superior premolars it is probable that there were four of these also. There are three strong incisors in each premaxillary. No canine tooth is preserved, but the posterior suture of the premaxillary bone is so wide as to point to an equally stout anterior part of the maxillary, fitted to support such a tooth. The dental series increases regularly in size, from before backwards, the last being a little larger than the penultimate. The crowns of the molars exhibit on the outer margin a single, acutely-angled crescent, directed inwards, with a conic lobe alongside of, and anterior to its base, representing a second external crescent. The crescent lobe proper is large and very obliquely directed, so that its external face is almost horizontal. The apex of its companion cone is continuous with its posterior margin, so as to be undistinguishable from it in some cases. The inner crescents are represented by a wide angular ridge, which is at a lower level than the exterior, and is little or not developed on the posterior side of the crown.

Its inner-plane face is horizontal, or even ascending in one species. In the premolar teeth of *B. radians*, the external crescent lobe is single and symmetrical. As the crown contracts inwardly, a second inner crescent lobe has a trihedral form, while in one more anterior, the inner is much reduced. The inferior premolars are all two-rooted, and form an uninterrupted series. The basis of the molar part of the zygomatic arch originates opposite the adjacent parts of the penultimate and last molars. The premaxillary bone is massive, and with but little area for attachment with its fellow in front. The incisor teeth are large, with subcylindric roots, and their alveoli are well separated. In one, perhaps superior, the crown is expanded transversely, with convex cutting edge.

In the *humerus*, the deltoid hook is developed, but is not much elevated above the plane of the head. It originates from an external expansion of the head, which bears a shallow cotylus, separated from the head by a low, curved, subtransverse ridge. The condyles of the humerus do not support any trochlear ridges. An almost perfect femur of *B. radians* is preserved. The third trochanter is not very prominent. The little trochanter is little developed; the great trochanter is large but does not equal the head. The latter is subglobular, and the ligamentous fossa extends to its rim. The distal trochlear surface is prominent, the inner edge more so than the outer. Its articular surface is broadly continuous with those of the condyles; a slight emargination of the outlines only marking the usual constriction on each side. In this it resembles *Cervidæ* and some *Antilopidæ*. The inner condyloid surface is cut off by the emargination in *Toxogen* and *Bos bubalus;* the emarginations are deep, but do not cut off either in *Equus*, *Camelopardalis* and three species of *Bos;* while they are so deep as to cut off both in *Rhinoceros*, 5 sp., *Hippopotamus*, *Bos brachycerus*, *B. sondaicus* and *B. sebynicerus* and in *Catoblepas*.

BATHMODON RADIANS. Cope. Sp. nov.

Represented by portions of several individuals, which indicate an animal varying from the size of the ox to that of the Javan Rhinoceros.

The transverse diameters of all the molars exceed their longitudinal. In the penultimate, which may serve as a type, the superior or outer plane of the inner crescent ridge extends along about .66 of the posterior of the outer crescent. In the last molar this surface is very wide on the posterior and inner side of the external crescent; it then contracts, and expands again on the posterior side, its outer bounding crest reaching to the external margin of the crown.

Besides these points, the molars possess a strong cingulum along the anterior base of the crown, which unites with the surface near the inner proturberance of the latter in the penultimate; in the last molar it reappears, forming a short lobe on the posterior face. The enamel where not worn is slightly rugose.

A posterior premolar has a cingulum on the inner obtuse apex. The crest of the inner crescent, descending on each side of the apex of the

outer, forms a cingulum-like ledge at its base as far as the angle formed by the descent of the apex of the outer crescent. The outline of the corner of this tooth, viewed from above, is narrow cordate, with obtuse apex. The convexity of the outer crescent inwards is very strong, and the base of the crown is externally two-lobed. Enamel striate rugose. In a more anterior premolar (with three roots) there is no internal cingulum, and the crest of the inner crescent is not carried to the external basis of the tooth, and is entirely wanting on the posterior face of the tooth. The external crescent is more vertical and less concave. Outline of crown subtriangular.

The premaxillary bone is elongate, flat, and with a sloping superior face, which rises gently inwards. The bases of the incisors stand obliquely outwards. The inferior surface is flat, and the basis of the broken palatal spine is rather small. An incisor tooth has a transversely diamond-shaped crown, slightly twice concave on the inner face, strongly convex on the outer, with a faint external cingulum near the external angles. Enamel obsoletely striate.

MEASUREMENTS. (NO. 1.)

	M.
Longitudinal diameter last superior molar	.035
Transverse " "	.0455
Longitudinal " penultimate	.032
Transverse " "	.039
Longitudinal " posterior premolar	.024
Transverse " "	.034
Longitudinal " anterior "	.0215
Transverse " " "	.0265
Length premaxillary bone	.082
Transverse width posterior suture	.028
Width premaxillary at middle "	.043
Length basis last two inferior premolars	.057
Transverse diameter edge of mandible at first premolar	.017
Diameter condyles of femur	.104
" heads great trochanter	.130
" head alone	.062
" shaft with third trochanter	.076
Supposed length femur (16.75) inches	.415
Transverse diameter head of tibia	.092
Antero-posterior " internal	.061
" " external	.045
(?) No. 2.	
Longitudinal diameter head of humerus	.138
" " of outer cotylus and tuberosity	.055

The other remains of this animal will be more fully described and the whole figured, shortly. They were discovered by Dr. F. V. Hayden, in tertiary beds of the Wahsatch Group, near Evanston, Utah.

BATHMODON SEMICINCTUS. Cope. Sp. nov.

This species differs from the last in several particulars of dentition. The interior ridge (homologous with the inner crescentic) bounding the middle plane of the superior molars, is not continued on the posterior face of the tooth, but curving inwards joins the outer crest at its apex. The outer crest terminates in a conic tubercle anteriorly on the external face, the rudiment of the anterior crescentic ridge appearing as a low ridge from the side of the posterior one, and rising to a point on the anterior margin of the crown. There is no cingulum round the anterior base of the crown. The latter is as long as wide. The inner crest is reduced to a mere angle, and its posterior face is not basin-shaped but rises to the crest of the inner crescent. The outer face of the latter is sub-horizontal with rising apex, and is concave transversely. Its anterior outer base is narrowed but is less elevated than the posterior.

Measurements.	M.
Length basis crown	.0225
Width "	.022
" exterior crescent	.012
Depth " "	.02

This animal was not more than half the bulk of the last; its size was about that of the *Tapirus terrestris*. The differences in dentition which it presents are so marked as compared with the last species, as to induce me to believe that it will be found on fuller acquaintance to belong to another genus. This may be called *Loxolophodon*. Other remains belonging to these species, or relating to it in size, are contained in Dr. Hayden's collection, but cannot now be referred to with certainty.

From the Wahsatch Beds, near Evanston, Utah.

Especial interest attaches to these fossils from the fact that, they belong to the oldest of the tertiary periods of North America. The Wahsatch Group, according to Dr. Hayden, underlies the Bridger Group, which has yielded so many mammalian species to the researches of Leidy and Marsh. These have been supposed to be Eocene, so that the age and species here described is not later than that. The character presented by the molar teeth are very peculiar, and indicate not only a new genus, but a new family. This has a remote affinity only to the group of *Palæosyops Titanotherium, etc.*

ON TWO NEW ORNITHOSAURIANS FROM KANSAS.

BY EDWARD D. COPE.

(*Read before the American Philosophical Society, March* 1, 1872.)

The species about to be described resemble, in their large proportions, the large pterodactyles of the English chalk and green sand. The specimens at my disposal consist chiefly of portions of the anterior limb, of metacarpals and phalanges. Some of the phalanges of the claw-bearing digits are remarkable for their relatively large diameter, a peculiarity

stated by Seeley to be found in the species of his genus *Ornithochirus*. As it is not likely on other grounds that the species of the Niobrara cretaceous strata belong to the genus *Pterodactylus* of Cuvier, which is chiefly known from the Jurassic period, I place the Kansas species for the present in *Ornithochirus*, as established by Seeley.

ORNITHOCHIRUS UMBROSUS. Cope.

Represented by the distal portion (ten inches) of the wing finger metacarpal; the proximal portion (eight inches) of the first phalange of the same digit, with two phalanges of claw-bearing digits. The distal condyles of the first named bone are separated by the usual deep groove above and below, and wind separately to their terminations on the inferior face. The narrow base which supports the inner condyle is bounded posteriorly by an acute edge; directly outside of the base of this ridge is a deep groove or foramen, which is bounded next the external condyle by another ridge which rises to the base of the inner condyle on the trochlear side. The transverse diameter of the condyle is M. 0.043 or 17 lines.

The proximal end of the first phalange is perfect, but flattened by pressure. It presents the two usual cotyloid cavities well separated by an elevated ridge. Anteriorly, it presents an elevated crest for muscular insertion. This terminates abruptly, and is followed distally by a deep notch. Distal to this is another prominence of the bone also probably an insertion. Antero-posterior diameter (flattened), 24 lines.

The claw phalange is short and wide; both its articulations are simple and concave. Both outlines are keeled, one very strongly at one end, and at the other presenting beyond the articular surface, a wide prolonged process for muscular insertion. Length phalange without process, thirteen lines; process, four lines; diameter, widest extremity, eleven lines. This indicates a very stout digit. The other digit is penultimate, and is remarkable for its small size, perhaps indicating an external rudimental digit. It is only supposed to belong to the anterior limb, from its having been found with the preceding bones. It is more slender than the other, and differs in having convex distal articulation, divided by a trochlear groove, and the concave proximal one in like manner divided by a trochlear carina. Length, nine lines; proximal depth, three lines.

This species is the largest Pterodactyle as yet known found on our continent, the end of the wing metacarpal exceeding in diameter that of the species described by Professor Marsh, from the same region, by 4. lines.

From near Butte Creek, from the yellow chalk.

ORNITHOCHIRUS HARPYIA. Cope.

Established on wing metacarpals and phalanges of three individuals. The articular extremities indicate a species from one-half to two-thirds the size of the last named. Those of the metacarpal are very prominent above as well as below, and there is no distinct ridge in the trochlear groove between them. The inner condyle does not stand on a base with an acute posterior ridge, but overhangs a rather obtusely-edged support.

There is no second ridge on the outer (trochlear) side of it. The same condyle terminates abruptly posteriorly on the superior face of the shaft. Width of condyles in No. 1, eleven lines; in No. 2, thirteen lines; vertical diameter, inner condyle, eleven lines (No. 1); transverse diameter shaft above, eight lines.

The proximal articular surfaces of the proximal wing phalanges are deeply concave, the inner protected by an elevated margin behind; that of the outer, much lower. They are separated chiefly by a deep emargination, but on their short adjacent portions by a low ridge. The process for ligamentous insertion is well developed. The distal extremity is slightly widened, and its articular surface is wedge shaped with very convex base. Its surface is slightly concave in both directions and without median ridge. The margin of the shaft terminates in a short tuberosity bearing articular surface. Transverse diameter, sixteen lines. Length of shaft preserved, but incomplete, nine inches, one line.

This species is about the size of the Pterodactyle found by Professor Marsh in the same region,* and probably belongs to the same genus, and possibly to the same species. This, however, cannot be definitely ascertained as his species is imperfectly described, all the characters adduced except the measurement being generic. The name given by Professor Marsh has also been previously used, both in this genus and in *Pterodactylus*, and must therefore be given up.

Remains of the two *Ornithochiri* above described are not rare in the yellow chalk of the Niobrara Group, and those obtained were mostly from different parts of the course of the bluffs of Butte Creek.

A DESCRIPTION OF THE GENUS PROTOSTEGA, A FORM OF EXTINCT TESTUDINATA.

By Edward D. Cope.

(*Read before the American Philosophical Society, March 1st*, 1872.)

The present article introduces to the system a new form of Testudinata of a character not heretofore found in a fossil condition. Its affinities will be more fully discussed at the end of the description, but they appear to belong to the *Sphargididæ*. This family is represented, in our present knowledge, by but one genus and one species of the recent seas. It is one of the most generalized, or in special characters, the most aberrant of the order of the tortoises, and the discovery of an extinct ally, even as far down in the series as the cretaceous period, is not surprising.

The remains preserved belong to a single individual, and include many portions of the cranium, five vertebræ more or less incomplete, the scapular arches of both sides with the coracoid bones; both humeri perfect, with nine phalanges, ten ribs, one vertebral (?), and ten marginal bones; parts or wholes of four large lateral (?) dermal bones, with five distinct

*See Am. Jour. Sci. Arts, June, 1871.

bones of unknown reference. There are also some slender curved bones which probably pertain to the plastron.

As the bones were exposed by excavations in the yellow cretaceous chalk, sketches of their positions and relations were made, which aid materially in the restoration of the animal. The upper layer of bones were those of most irregular form, as cranial and limb bones. Mingled with these, but often beneath them, were the ribs, while underlying all, were the large flat pieces here described as dermal. Adhering to the inferior surface of these was a layer of thin oyster shells with parallel striate surface, perhaps *Inocerami*. The ribs presented their heads upwards; so that taking all points into consideration, there is little doubt that the reptile was entombed on its back.

The texture of the bones is peculiar. There are nowhere to be seen medullary cavities, and the bone is spongy, but very finely so, the tubules at the largest being equal in diameter to an ordinary pin, and generally considerably smaller. They are arranged in concentric series. There is no thick dense layer of the bone as in other tortoises, but an extremely thin one, which is hard and sculptured on the surface with minute grooves or pits. The tissue of the bone is very fragile, and has a fracture like the mineral enclosing it. Many of the bones, especially those of the dermal skeleton, are extremely attenuated on the margins, being no thicker than writing paper.

There are twelve *marginal bones*. They are all characterized by their laminar form. The thinnest are those furthest removed from the middle of the sides. They consist of a single lamina slightly thickened within the margin, producing a slight convexity of the lower side. The proximal part of the bone is an extremely thin plate with radiating ossification, and consequently more or less serrate margin. It extends some distance over the extremity of the rib, whose apex is received into a half pit or acuminate groove with abrupt termination, about one-sixth the width of the bone from the margin.

In following the marginals to the middle of the side, the edge, as usual, increases in thickness. The lower side becomes more convex, and the upper slightly concave. The edge is acute, and a very open interior entering angle at the middle. The lateral extremities of the marginals are irregular, terminating in a double series of closely packed digitations, which terminate freely, and enter into no suture. The pit receiving the extremity of the rib approaches the margin, which now develops an inferior lamina of bone. This encloses the end of the rib, and thins out laterally in contact with the superior plate. At first the inner lamina is short; later it is almost as extensive as the outer part of the marginal plate, causing the double appearance when fractured. As the marginals thicken, a distinct inferior plane becomes distinguished, separated from the interior face by an obtuse angle. The upper face near the margin is more concave. In the thickest and inferior face is also somewhat concave, and the edge quite acute. The lateral extremities consist as before of packages of digitations which easily break out.

A single nearly bi-lateral bone of this series appear to be either nuchal or caudal, but as it has no sutural connection with any other it is not easy to determine which is. Its marginal length is much less than its transverse extent, which consists chiefly of a flat lamina. The marginal part is a little thickened and bi-laterally concave below, and correspondingly convex above. The margin is thin and acute. A few grooves radiate at a distance from the middle towards the margin. The lack of concave excavation of the margin would incline the balance in favor of the view that this bone is the caudal.

A very long gently curved bone is probably the marginal extending on one side of the nuchal. It is nearly twice as long as the others, and has an extensive and thin superior lamina. Its (?) anterior part is in one plane, but the margin soon thickens and displays a rather wide infero-external face. It appears to have had an inferior lamina on its posterior half, which made an angle with the face just described. An oval cavity included, looks as though designed for the apex of the rib.

The variation in the lengths of these marginal bones is noteworthy. I give measurements, premising that a few lines may be added to the extremities of some for lost digitations:

	M.
Length of long anterior (11 in.)	0.28
Width " " (some lost)	.135
Length of lateral with inferior face	.195
Width " (much lost)	.110
Length " with narrower inferior face	.206
Width " (much lost)	.115
Length of one with interior lamina	.14
Width " (some lost)	.086
Length of a thinner, no inferior plate	.193
Length still thinner, " "	.182
Width of " (broken)	.137
Length thinnest	.162
Width " (nearly complete)	.160
(?) Caudal length	.117
" width	.150

The shortness of the marginal with large interior lamina is noticeable. as also the same peculiarity in the caudal. As compared with marine turtles, difference is to be observed in every particular. Such are the lack of sutural union, the laminar character; the great extent of the superior and distinctness of lower laminæ. There is no trace of epidermal sutures visible anywhere.

A single symmetrical plate appears to have belonged to the middle line of the back or nape. It was sub-triangular in outline, all the margins very thin, and with an obtuse keel extending on the middle line, on the posterior (or anterior) two-thirds to the apex. This ridge disappears in (?) front by a gradual expansion. The surface is marked by lines of minute

pits and grooves, which radiate from the base at the (?) front of the ridge. Length, M. .135; width, .21.

The *lateral dermal bones* preserved, are two entire, and large parts of one or of two others. They have an irregular oval outline and are slightly dished on the inferior surface or that next the ribs. The upper surface is more convex longitudinally, from the thickening of the bone. The margins are irregular from the projection of many digitations. Some of these are broad and flat, others are narrow. They are frequently two deep, and the fissures separating them occasionally extend far towards the middle of the bone. The convexity assumes the form of a low ridge towards one end of the bone. At the point where this reaches the margin, the latter is in all the four plates, thickened, and composed of several layers of packed osseous radii. When found, the ribs laid across these shields; one of them occupying the position of a radius to one of them. These shields are much larger than the marginal bones.

	M.
Length "No. 10" (21 inches)	0.535
Width " (broken)	.400
Thickness at middle	.014
Length "No. 9"	.530
Width " (much broken)	.530
Thickness at the middle	.013

The lengths and breadths given are a little below the truth, owing to the loss of the exceedingly thin margin.

Turning to the endo-skeleton, the *vertebræ* deserve mention. There are more or less complete examples of five of these: in two, both centrum and neural arch; in two, neural arch; and in one, centrum, are preserved. These have been recognized chiefly by their neural arches, which are separate. They are in form something like an X, the extremities of the limbs carrying the zygapophysal surfaces. The only point of contact with the centrum is a wide process which stands beneath the anterior zygapophysis, and spreads out foot-like obliquely forwards and outwards, to beyond the line of its anterior margin. Its surface extends nowhere posterior to the surface of zygapophysis above it, but a little further inwards. Its outer margin rises ridge-like to the under side of the neural arch, and each one forming a semi-circle forms the boundary of the neural canal, and turning outwards forms the *inner* boundary of the posterior or down-looking zygapophyses. The space between these apophyses is roofed over, so as to produce a shallow zygantrum, which, however, only seems to roof over the deep emargination of the neural arch of the vertebra immediately following. The anterior zygapophyses are often broken away, so that the neurapophysial supports look like the missing pair, when the difficulty ensues that both pairs look downwards. The top of the neural arch is in two cases broad and flat; in two others there is an obtuse keel.

The centra apart from their arches are puzzling bodies, especially since

in the present case they are somewhat flattened by pressure. They differ materially in size, one of them being twice the size of the others. The smaller ones are of the ball and socket type and have a deep longitudinal groove on each side. The thicker portion of the centrum forms the inferior boundary of this pit-groove, while a thinner portion, possibly a diapophysis limits it above. It is, however, thin, and had no great length. There is no sign of chevron bones and articulations, so that these vertebræ may have been cervical. Their bodies are, however, shorter and wider than in those vertebræ of any known tortoise. A groove on the upper surface represents the neural canal; while a flat portion on each side in front, supports the neurapophyses. The large centrum exhibits the superior groove, and antero-lateral platform for support of the neural arch. One end is cupped obliquely, while the other is nearly plane, with the same obliquity and a slightly raised margin. Its outline is sub-triangular. The lower side of this centrum possesses a short keel posteriorly. The sides exhibit no pit, but have a thin edge, which is concave behind the middle, and then turn outwards. I can see no articulation for a rib.

The forms and characters of these vertebræ resemble *Sphargis* more than anything yet described. Either the large or the small, or both must be referred to the dorsal region; in this case the concavity of one extremity is a new feature among tortoises, so far as known. The great freedom of the arch from the centrum is very peculiar, while it is probable that the articulations of the ribs were to the middle of the side of the body, and not to the adjacent parts of two bodies, and may have been (see below) to processes or diapophyses.

	M.
Length medium centrum	.037
Width " "	.060
Length between margins of zygapophyses do	.060
Width " anterior " "	.070
" " posterior " "	.047
" " anterior basis of arch	.070
" arch at middle	.028
Length " "	.040
Width posterior zygapophyses, No. 2	.048
" of arch	.025
Length "	.025
" of anterior foot (oblique)	.02
Length centrum of large one	.06
Width " " "	.094
" neural canal " "	.017

Ten *ribs* were recovered. These are slender and rather flatter than in most reptiles, but without the peculiar form, characteristic of tortoises and turtles. They are most expanded proximally, the bone spreading into a lamina, from the tubercular region, extending laterally and prox-

imally some distance beyond the head. The superior plane of this expansion is continuous with that of the rib, and is flat; the head of the rib therefore turns downwards and inwards from it, to join the vertebra. Now the extent of the inner part of the lamina is such that, were the head articulated to any of the centra discovered, the former would interfere or overlap. They may, therefore, have been articulated to diapophyses. The expansions are serrato-digitate on the margins, and exhibit radiating grooves and ridges in some places, on the superior aspect. The lengths of these ribs are not so great as the proportions of some of the other bones would indicate.

	M.
Length "No. VI." (16 inches)	0.510
Width at head	.140
" of "	.040
" at middle	.055
" at extremity	.040
Length "No. II."	.390
Width " just below the head	.100
" at middle	.037
Length "No. IX."	.380
" proximal to head	.060
Width at middle	.08

In the rib "No. II." the head is turned obliquely to one side, indicating that the rib diverged at a strong angle from the vertebral column, in fact not more than one of 45°. This is then an interior or posterior rib, probably the latter, since the shell is usually expanded chiefly in that direction. All the ribs are flat above, and convex inferiorly.

Both sides of the *scapular arch* are complete, except the sutural portions of coracoid and scapula of one side. The scapula and procoracoid make a very open angle with each other, both being stout; the scapula the longer, with grooved sculpture at its proximal end. The procoracoid is a little the shorter. The glenoid cavity and coracoid suture are almost sessile at the union of the scapula and procoracoid. The coracoids are very elongate, almost equal to the ribs, and not stouter except at the extremity. It is expanded into an oblique head proximally; the shaft is flat, one edge thickened or truncated, the other thin. The distal portion is scarcely expanded, being more slender than in any recent Testudinate known to me.

	M.
Length scapula to glenoid cavity	0.213
Width " proximally	.045
Length procoracoid to articular surface	.106
Width " distally	.060
Length coracoid	.400
Width proximally	.086
" medially	.047
" distally	.080

The elongate coracoid resembles most, among recent Chelonians, the marine genus *Chelone*, while the sessile glenoid cavity and short procoracoid with open angle are entirely different. In these points this genus is more like terrestrial forms as *Testudo*, or less like *Emys*.

Both *humeri* are entirely preserved. They appear to have been somewhat flattened by pressure; but when unaltered they were no doubt flat, with stout proportions. They have a globular head with an immense trochanter which projects much beyond it proximally. The shaft is there much contracted, and expands again distally to the broad and very convex articular extremity. Opposite the narrow part of the shaft, the small trochanter appears on the inner side, forming an elongate ala. The long axis of the humerus is not straight, the proximal and distal portion making an angle of 110° with each other.

	M.
Total length humerus (1 ft.) straight	0.300
Length " from head	.296
Width at head	.156
" of "	.073
Least width shaft	.076
Greatest distal width	.132
Length basis little trochanter	.080
Thickness at shaft	.031

The flatness of this element and situation ot the large trochanter in the general plane are characters of the *Sphargididæ*; the great constriction medially and expansion of both extremities remind one of the *Mosasauroid* humerus.

Of bones of the fore arm there may be one, but the bones next in size to the humerus look more like metacarpals or metatarsals. Two of them were found together in position and their relative positions were not like those seen in the fore-arm of sea-turtles. They measure over seven inches in length, and are strongly concave on their adjacent sides. One of them is slightly concave on the outer side, the other convex, the convexity being at $\frac{2}{3}$ the length from one end. The ends of both are a little expanded and one end of one displays a double or trochlear extremity. The same end of the other is injured by pressure. A still larger metacarpal-like bone is relatively more expanded at the ends. The articular surface of one of these is wide at one end, and much narrowed at the other. The smaller bones, undoubtedly phalanges, are six in number. They are quite slender, a little expanded at the ends, and flat.

	M.
Length largest	0.165
Width do. at extremity	.065
" " middle	.032
Length longest of pair	.180
Width, extremity	.050
" shaft	.027

	M.
Length phalange	.032
Width, extremity	.032
" shaft	.018
Thickness shaft	.011

These measurements indicate for the fore limb a total length of 4.52 feet (M. 1.347) if proportioned as in *Chelone;* this would give an expanse of 11.3 feet. If, however, it was constructed on the plan of *Sphargis*, the expanse would be nearly seventeen feet.

Several instructive *cranial bones* were preserved. These are the maxillary and distal part of the dentary of the left side; the posterior part of the left mandibular ramus; quadrate bones and adjacent pterygoids and squamosal, one side with the columellar plate also; right post-orbital bone and part of the left. Also some probably hyoid elements.

The *maxillary bone* and dentary present a considerable extent of the alveolar margin. This is remarkable in being thin, sharp and elevated, without horizontal portion. The former bone is but little incurved to the premaxillary suture; its anterior outline is elevated and vertical, the nostrils entering opposite the probable middle of the orbit. The palatal plate of the maxillary has no great antero-posterior extent, so that the inner nares are opposite the anterior part of the orbit. The latter presents only the anterior and inferior outlines in the specimen. The part of the maxillary below it is very narrow, and weaker than either *Sphargis* or *Chelone*. The cutting edge has a very open sigmoid flexure, suborbital part being turned inwards, the anterior part a little outwards. The osseous rim of the orbit projected considerably beyond the plane of the maxillary anteriorly.

The *dentary* bone is very deep anteriorly, and like the maxillary is a thin vertical lamina. The lower anterior angle is truncated by an acute concave margin. This is the anterior extremity of the symphysis. This suture occupies the inner face of a triangular area which extends but a short distance on the lower margin of the ramus, and then passes upwards and backwards for a short distance on the inner face of the ramus. That portion above the symphysis diverges outwards, thus producing a deep notch at the symphysis, as though designed to receive a beak-like projection of the premaxillaries. The cutting edge has a slight sigmoid flexure corresponding with that of the maxillary; it rises into a projecting angle.

The posterior part of the ramus displays the cotylus, and in front of it a deep long fossa behind the articular bone. There is no angle nor coronoid bone, as in all marine turtles. The superior margin of the *dentary* is thicker posteriorly than in front, and its outer wall is produced backward as a thin lamina, covering the surangular almost to the posterior end of the ramus. The *angular* is, as in recent forms, a narrow wedge-shaped piece below the dentary and surangular. The posterior edge of the surangular projects behind the dentary and exhibits an acute convex

edge rising forward. It supports a small part of the articular cotylus on its inner face. Most of this portion occupies the extremity of the *articular*. The latter sends a stout lamina obliquely upwards and forwards to the lower posterior part of the dentary.

The *quadrate bones* are of a peculiar form. They exhibit the usual posterior curviture above, with shallow funnel-like fossa for the tympanic cavity. It presents two strong ridges anteriorly, an inner and an outer which encloses a deep vertical concavity. The inner exhibits the suture with the pterygoid bone, the outer with the zygomatic. The superior border of the quadrate within the sqaumosal is massive and not inflated. Its surface is thickest where the usual articulation with the opisthotic exists. The posterior horizontal is short and deep. The transverse part of the bone which supports inferiorly the exterior part of the condyle is thin, and disappears above the antero-posterior portion. From its middle upwards it supports the *zygomatic*. The latter has no great extent anteriorly to its malar suture, and its inferior margin arches high above the line of the condyles of the quadrate.

The *pterygoid bones* are subtriangular in outline, with concave sides, an emarginate base, and a very obliquely truncate apex, which articulates low down on the quadrate bone. Both margins are thickened and rounded, the superior as boundary of the foramen ovale. The posterior margin of the plate-like columella overlaps it on the inner side, deeply notching it; on the outer side, the suture is zigzag and transverse. The superior part of the bone is produced like a flat rod, and at its end exhibits a squamosal suture for union with what is in the snapper a postero-inferior rod-like prolongation of the columella. No such process of the columella appears to exist in this species. The *columellar plate* is half as large as the pterygoid, and exhibits the oblique suture in front for the descending lamina of the parietal.

The *postfrontal* bone of the left side is preserved entire, and the inferior portion of that of the right. The inferior margin for the malar is the longest and is straight. The orbit is excavated in part from its anterior margin, while the supero-posterior is a continuous curve. The inferior suture is a groove, whose inner bounding wall is convex, but rises past the straight outer to an inner ridge, which probably approaches the ectopterygoid region. A large sutural face for the zygomatic exists at the tower posterior angle, and an elongate one above for the parietal. The inner face is concave, indicating a large temporal fossa as in *Sphargis* and *Chelone*.

Two bones of opposite sides of the cranium are either those portions of the pterygoids which bound the temporal fossa below in front, or those portions of the maxillary bounding the palatine foramen. As the free margin is much thickened they are probably the former. Their inner or thinner lamina is marked for squamosal suture with other bones, perhaps columella and palatine.

Measurements of Cranium.	M.
Depth premaxillary suture of maxillary	0.06
Length from do. suture to inner nares	.068

	M.
Depth maxillary below orbit	.035
" dentary at symphysis	.078
" notch of do. do	.044
" dentary behind symphysis	.095
" " at coronoid region	.085
" ramus at front of cotylus	.061
Length pterygoid fossa of do	.06
" cotylus do	.07
" postfrontal on inferior suture	.195
Depth " at boundary of orbit	.136
Thickness " lower suture	.019
Length from orbit (oblique)	.115
Length right quadrate	.140
Width (antero-posterior)	.110
" of condyle	.064
Length right pterygoid superiorly	.155
Depth do. at inner columellar angle	.100
Length (oblique) of columella	.085

Restoration. Better materials exist for the restoration of this species than is usual in the case of most extinct *Testudinata*. The cranium was .50 M., or 24⅝ inches in length. If the neck and carapace were related to it, as in the genus *Chelone*, the total would be as follows:

	Inches.
Cranium	24⅝
Neck and carapace	138⅞
Total 12.83 feet	154⅞

an extent not far from the expanse of the flippers above given, viz., 11.30 feet. The shortness of the cervical vertebræ indicate that the proportions of the neck were not dissimilar to those of the existing marine genera. The flippers were probably similar to the same; of the hind limbs nothing can now be stated. The shortness of most of the ribs considered in connection with the length of the carapace, is remarkable. Thus the longest rib measures .51 M. or 16 inches; width of lateral marginal beyond apex of rib 2.25 inches; width of vertebra 3 inches, which is, however, covered by the expansion of the rib, included in this case in the length 16 inches. Total width of carapace at middle, 36½ inches. Length of carapace 118 inches; or wide 3 feet ½ inch; length 9 feet 10 inches. This outline, three times as long as wide, is justified in measure by the size, especially the lengths, of the marginals, which if placed end to end, would measure on one side of eleven pieces, if each were as long as the median, 8.5 inches $\times$ 11 = 7.8 feet. Some of the posterior marginals are shorter than 8.5 inches, while some of the anterior appear to be longer. The length 8.5 may then be taken as an average. But they formed the circumference of an open arc, so the axial length of the carapace should be placed at a lower figure than the above. This proposition may be offsetted by the fact that the marginals were not united to each other and

exhibit no indications of contact. The length of 7.8 feet, for the carapace is not then too much, and estimating from the size of the head is too little. We can then safely conclude that the carapace of this turtle is more elongate and narrowed than existing forms. Thus in *Chelone mydas* the carapace is six-eighths as wide as long.

It remains to discuss the question of the age of the specimen. It might be objected that the absence of carapace, and the radiate character of the margins of many of the bones indicate that our type specimen is young. To this it may be replied (1), that it is in the (?) sternal bones unlike the young of any known type, when certain of their bodies do at all times exhibit smooth margins as boundaries of the points of exit of the limbs; moreover, it is possible that these plates were dorsal. (2) The superior or inner extension of the marginals exceed that of any known tortoise in the adult condition. (3) The articular bone is ossified. (4) Separate ribs should be discovered among extinct tortoises as an adult character, on theoretical grounds, the more as it exists in one recent genus (*Sphargis*, vide Wagler).

Affinities. In discussing these, one point heretofore left doubtful may be first considered. The large flat elements described as lateral dermal bones; are they ossifications of the dorsal or ventral integument? They were found below all the other bones, and nearly all the ribs laid on them with their heads turned upwards. This rendered it probable that the shields were dorsal, and that the animal was entombed on its back, and a coracoid, which was afterwards found lying immediately on the largest bone (No. 10), crossed in its course parts of two ribs. This could not have been the case had the shields been ventral. An examination of the shields does not reveal any conformity to any known type of Testudinate plastron. The bones radiate in all directions, leaving no margins for fore and hind limbs, or for a median fontanelle, still less for suture with each other.

Should these bones then be regarded as dorsal, they constitute a character not previously noticed in the order, but one whose homologue is seen probably in the dermal shield of bony tesselated plates seen in *Sphargis*. The other points of affinity to *Sphargis* are the distinct ribs; the thin laminiform jaws with cutting edges; the quadrate bone with such a strong anterior concavity; the elevated position of the zygomatic bone; the form of the humerus. Points of special resemblance to *Chelone* are: the short posterior superior portion of the quadrate; the entire edge of the maxillary bone; the deep dentary. The points in which it differs from both, are numerous. They are: the dorsal shields, the marginals, the notched symphysis, etc.; the shortened articular end of scapula; the elongate form of the carapace, etc.

The constant separation of the ribs, and the short vertebræ, are characters which are more like those possessed by other reptiles, than those characteristic of *Testudinata*. The presence of dermal dorsal bones is of the same kind. The genus *Protostega* then belongs near the *Sphargididæ* in the suborder *Athecæ*, and is in some points to be approximated to the *Chelonididæ*.

Distribution. This fossil was found near Ft. Wallace, W. Kansas. It was entirely recovered by excavating. The edges of one of the large bony shields were seen projecting from a bluff near Butte Creek, and was followed into the chalk rock with pick-axe and shovel with the result already indicated. The large bones were exposed in an entire condition, but were much fractured in the attempt to lift them from their bed. Though carefully packed, the transport of 1500 miles still further injured them, and the portions described were reconstructed of over 800 pieces by myself. One of the bony plates was broken into 108 pieces, the ribs into 183, the marginals into 146, etc.

This species may be called *Protostega gigas*, Cope.* A second species appears to have existed during the Cretaceous period, as indicated by a humerus from near Columbus, Miss., sent by Dr. Spillman to the Academy of Natural Sciences. With it were received bones of the Mosasauroid *Platecarpus tympaniticus*, and Dr. Leidy, who described them,† regarded all as belonging to one animal. On this basis he expressed the opinion that the fore limbs of the *Pythonomorpha* were natatory. That this view was correct I proved by study of the skeleton of *Clidastes propython*, and it now appears that the fore limbs of the latter were the first ever described.

The humerus of the Mississippi *Protostega* (see Leidy, l. c., Pl. viii., Fig. 1–2) is more elongate than that of the *P. gigas*, and is less contracted medially. The (great trochanter or) deltoid crest is longer and stouter, and the process answering to the little trochanter is more prominent, rounded, and proximal in position. It indicates a rather smaller animal than the Kansas specimen, and may be named *Platecarpus tuberosus*.

A third species is represented by a humerus found in the cretaceous green-sand of New Jersey. It was a huge animal, exceeding not only the species just described, but even the Indian *Colossochelys atlas*, usually regarded as the largest of the order. It was regarded by Leidy as pertaining "to the great *Mosasaurus*," but Agassiz regarded it as Chelonian in affinities, naming it *Atlantochelys mortonii*.‡ Its great trochanter is very prominent, as in *P. tuberosus*, but the lesser one is smaller and nearer the condyle or head. The shaft is still more slender and not flattened, but subcylindric. It may be called *Protostega neptunia*. It is figured by Leidy, l. c. Pl. viii. fig. 3, 4. In this connection may be recalled the vertebræ of a gigantic animal from the New Jersey Cretaceous, described by the writer as belonging to an extinct species and genus under the name of *Pneumatarthrus peloreus*. It is quite likely that these belonged to a turtle still larger than the *Protostega neptunia*. (See Proceed. Amer. Philos. Soc., 1870, p. 446.)

*Proceed. Amer. Philos. Soc. 1871, p. 173.

† Cretaceous Reptiles of North America, p. 42. Smithson. Contrib. 1864.

‡ This name was unaccompanied with the necessary description, and is hence useless to science.

Stated Meeting, March 15, 1872.

Present, 12 members.

Vice-President, Mr. FRALEY, in the Chair.

Prof. Edwin J. Houston, a newly elected member was presented to the presiding officer and took his seat.

Photographs for the album were received from Mr. George Davidson, U. S. Coast Survey, and from Prof. O. C. Marsh, of New Haven.

A letter requesting exchange of publication was received from Prof. C. F. Chandler, Editor of the American Chemist, dated School of Mines of Columbia College, corner of 49th St. and Fourth Avenue, New York, March 12, 1872. On motion, the American Chemist was ordered to be placed on the list of correspondents, to receive the Proceedings.

A circular letter was received from the Royal Academy of Sciences of Belgium, inviting the Society to assist at its Centennial Anniversary, May 28th and 29th next ensuing.

Letters of envoy were received from the P. O. Society at Königsberg, dated July 10, 1871, and from the Central Bureau of Statistics at Stockholm, dated Nov. 4, 1871.

Letters of acknowledgment were received from the Central Bureau of Statistics at Stockholm (81 to 85). Le Bureau des Longitudes, at Paris, dated Nov. 19, 1871 (82, 83); Feb. 14, 1872 (86). The Smithsonian Institute, Feb. 28, 1872 (87), and the Congressional Library, March 5, 1872 (XIV iii.).

Donations for the Library were received from the C. B. of Statistics of Sweden, the Society at Königsberg, the Royal Academy at Berlin, the K. K. Geological Institute and Anthropological Society at Vienna, the Royal Library at Munich, the Montsouris Observatory and Bureau des Logitudes at Paris, the Revue Politique, the Royal Geological Society of Cornwall, the Museum of Comparative Zoology at Cambridge, Mass.; the American Journal of Science, the New York Lyceum of Natural History, the Albany Institute, Prof. Chandler, the New Jersey Historical Society, the American Pharmaceutical Society, the Medical News and

Library, the Franklin Institute, the Penn Monthly, the Librarian of Congress, the Chief of U. S. Engineers, Senator Charles Sumner, and Prof. F. V. Hayden.

The death of Christian Olrik, of Denmark, a member of the Society, was announced by the Secretary.

The committee to which was referred the paper of Prof. Stevenson, on West Virginia Coal Measures, reported in favor of its publication in the Transactions, which on motion was so ordered.

A communication entitled, On some remarkable relations between the mean motions of Jupiter, Saturn, Uranus, and Neptune, received by letter from Prof. Daniel Kirkwood, dated Bloomington, Monroe County, Ind., March 11, 1872, was read by the Secretary.

On some Remarkable Relations between the Mean Motions of Jupiter, Saturn, Uranus, and Neptune.

By Prof. Daniel Kirkwood.

(*Read before the American Philosophical Society, March 15th*, 1872.)

It was noticed by the writer several years since, that 85 periods of Jupiter are nearly equal to 12 of Uranus,* and that 149 periods of Uranus are approximately equal to 76 of Neptune. If, therefore, n^{v}, n^{vi}, n^{vii} and n^{viii} denote the respective mean motions of Jupiter, Saturn, Uranus, and Neptune, these relations are expressed as follows:

$$12n^{v} - 85^{vii} = 76^{vii} - 149^{viii}, \text{ nearly};$$

or,
$$12n^{v} - 161n^{vii} + 149n^{viii} = -\gamma \quad . \quad . \quad . \quad . \quad (1).$$

With Newcomb's value of n^{viii} and the values of n^{v} and n^{vii} adopted in the *American Ephemeris*, we find $\gamma = 390''$. The equation,

$$32n^{vi} - 153n^{vii} + 121n^{viii} = -\gamma \quad . \quad . \quad . \quad (2),$$

was obtained by a process somewhat similar. Subtracting (2) from (1), and dividing by 4, we have

$$3n^{v} - 8n^{vi} - 2n^{vii} + 7n^{viii} = 0, \quad . \quad . \quad . \quad . \quad (3).\dagger$$

This equation, like that which exists between the mean motions of Jupiter's first three satellites, is doubtless exact. The mean motion of Neptune is less accurately known than those of the old planets. If we assume, then, that the received values of n^{v}, n^{vi}, n^{vii}, are correct,

* Runkle's Mathematical Monthly, January, 1860.

† Equation (3), without any account of its discovery, was given in Silliman's Journal, March, 1872.

the value of n_{VIII}, found by equation (3), is 7863″.983, differing from Newcomb's value (7864″.935) by less than 1″.

The corresponding relations between the *mean longitudes* of the four outer planets are sufficiently obvious. Thus,

$$3l^{\text{V}} - 8l^{\text{VI}} - 2l^{\text{VII}} + 7l^{\text{VIII}} = \varkappa = \text{a constant} \quad . \quad . \quad . \quad (4).$$

With a slight correction of the elements, it will probably be found that $\varkappa = 135^{\circ}$.

Again: the equation,

$$17n^{\text{VI}} - 228n^{\text{VII}} + 211n^{\text{VIII}} = 0, \quad . \quad . \quad . \quad . \quad (5).$$

found in the same manner as (1), is believed to be exact. Combining (3) and (5), we obtain

$$68n^{\text{VI}} - 325n^{\text{VII}} + 257n^{\text{VIII}} = 0, \quad . \quad . \quad . \quad (6),$$
$$257n^{\text{V}} - 844n^{\text{VI}} + 587n^{\text{VII}} = 0, \quad . \quad . \quad . \quad (7),$$
$$325n^{\text{V}} - 912n^{\text{VI}} + 587n^{\text{VIII}} = 0, \quad . \quad . \quad . \quad (6).$$

These equations indicate that in a cycle of about 11657.2969 Julian years, the planets Jupiter, Saturn, Uranus, and Neptune return to the same relative mean longitudes. The equations are all satisfied by the following values. The received values are given for the convenience of comparison. In column first $\delta'' = \frac{1296000''}{11657.2969}$.

THEORETICAL VALUES.		RECEIVED VALUES.	DIFFERENCES.
n^{V}	$= 109256''.719$	$109256''.719$	$0''.000$
$n^{\text{VI}} - n^{\text{V}} - 587\delta'' =$	43996.971	43996.127	$+0''.844$
$n^{\text{VII}} - n^{\text{V}} - 844\delta'' =$	15424.986	15424.509	$+0''.477$
$n^{\text{VIII}} - n^{\text{V}} - 912\delta'' =$	7865.083	7864.935	$+0''.148$

The received value of Jupiter's mean motion is here assumed to be correct. Any change would produce a corresponding variation in the remaining values. A revision of the theory of the orbits will, of course, result in some slight modifications. I believe, however, that the relations expressed by the preceding equations will be found strictly exact. If so, it must follow that *no three of the four outer planets can ever be in conjunction at the same time.*

BLOOMINGTON, IND., *February*, 1872.

Stated Meeting, April 5, 1872.

Present, 21 members.

Vice-President, Prof. JOHN C. CRESSON, in the Chair.

Letters of acknowledgment were received from the Royal Academy, Lisbon, Feb. 16, 1872 (XIII. iii. 81, 82); The Royal Institution, London, Feb., 1872 (XIV. iii. 87—XIV. ii. wanted); The Anthropological Institute of Great Britain and Ireland, London, March 21, 1872 (XIV. iii. 87); and the New York Lyceum, N. H., March 25, 1872 (XIV. iii.).

Letters of envoy were received from the U. S. Naval Observatory, Washington, March 25, 1872, and the New Jersey Historical Society, Newark, March 30, 1872.

Donations for the Library were received from the Russian Geographical Society, the R. Prussian Academy, the R. Belgian Academy, the Paris Geographical Society and Revue Politique, the Royal Astronomical Society, Meteorological Office, and Editors of Nature; the Argentine Astronomical Observatory, American Antiquarian Society, Essex Institute, Boston Old and New, American Journal of Science, American Chemist, Prof. James Hall, New Jersey Geological Survey, New Jersey Historical Society, Philadelphia Water Department, American Journal of Pharmacy, Gen. Hector Tyndale, the Franklin Institute, U. S. Naval Observatory, and Minnesota Historical Society.

Mr. Sol. W. Roberts, pursuant to appointment, read an obituary notice of the late Mr. Edward Miller.

The death of Mr. Samuel Jackson, on the 4th instant, in Philadelphia, aged 85, was announced by Mr. Fraley.

The death of Dr. Samuel H. Dickson, on the 31st ult., in Philadelphia, aged 72, was announced by Mr. Fraley.

The death of Mr. Elwood Morris, on the 2d inst., aged 59, was announced by Mr. Roberts.

The death of Prof. S. F. B. Morse, on the 3d inst., aged 81, was announced by Prof. Cresson.

Mr. T. B. Brooks, State Geologist of Michigan, read a paper on "Magnetism of the Rocks of the Marquette Re-

gion," near Lake Superior, which was referred to a Committee, consisting of Prof. Lesley, Dr. Genth, and Mr. Lyman.

Mr. Eli K. Price presented for record a notice of the Aurora of February 4th.

Mr. Chase communicated a note of new relations between the distances of the Moon from the Earth, and those of Jupiter and the Earth from the Sun.

Pending nominations, Nos. 689, 690, 691, 692, were read,

And the meeting was adjourned.

Stated Meeting, April 19th, 1872.

Present, 25 members.

Vice-President, Mr. FRALEY, in the Chair.

A letter, acknowledging receipt of Diploma, was received from Major R. S. Williamson, U. S. C. S., San Francisco, April 10th, 1872.

A letter, acknowledging the receipt of Transactions XIV. iii., and Proceedings No. 87, was received from the London Society of Antiquaries, Somerset House, March 28th, 1872.

Donations for the Library were received from Dr. Carl Neuman, of Leipzig; SS. Mantegazza and Finzi, of Florence (Archivis Anthro. e Eth.); M. Delesse, of Paris; the Revue Politique, London Nature, R. Geological Society of Ireland, Rev. Samuel Houghton, the Boston Society of Natural History, American Numismatic and Archæological Society, Prof. O. C. Marsh, of New Haven; American Journal of the Medical Sciences, News and Library, Penn Monthly, American Iron and Steel Association, Dr. Elder, Mr. Eli K. Price, Mr. George Davidson, the Coast Survey, Smithsonian Institution, and University of Virginia.

Prof. J. F. Fisher mentioned the death of the distinguished Genevan, M. Pictét de la Rive.

The Committee to which was referred the map and paper on a Coal District in Southern Virginia, reported recom-

mending the publication of the same in the Transactions; which was so ordered.

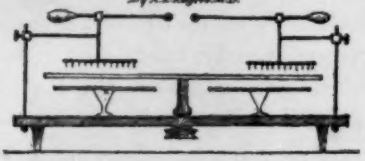
The Committee to which was referred the paper on the Magnetism of Rocks, &c., by Major T. B. Brooks, reported that, since the Legislature of Michigan had recently made an appropriation for the publication of the whole Report of the Survey of Major Brooks' District, they recommend that the Secretaries be requested to prepare an abstract notice of the paper for the Proceedings. The report was concurred in.

Prof. Chase, according to notice given, gave an explanation of his method of estimating the Sun's mass and distance by the energy of flames, with diagrams and tables.

Prof. Persifor Frazer, Jr., communicated the results of his spectroscopic observation of the late Aurora.

Dr. R. E. Rogers exhibited the capacities of a fine Holtz Electrical Machine, and described his proposed modification of its form for purposes of instruction.

Modified form of Holtz Electrical Machine.
By R. E. Rogers, M.D.



The prime plate is replaced by horizontal plates, laid upon wine glasses, or upon removable rubber standards. The rotating plate is made to rotate horizontally over them, its axis passing vertically downward through the table, the driving wheel being underneath. Two standards carry the combs, etc., and can be swung round out of the way. Every part of the machine can be removed in a charged state, to be tested and compared with its condition before removal.

The Secretary exhibited a water-color picture of a geological sectional model of Morrison's Cove, in Middle Pennsylvania, painted by Mr. J. W. Harden, C. and M. Engineer, of Philadelphia, and invited attention to the highly artistic style and beauty of the work.

Pending nominations, Nos. 689 to 692 were read, spoken to, and balloted for. New nominations, Nos. 693 and 694, were read. There being no further business, the ballot-boxes

were scrutinized by the presiding officer, and the following gentlemen declared duly elected Members of the Society:

M. Jean Baptiste Léon Say, Prefect of the Seine, Paris.
Mr. Lorin Blodget, of Philadelphia.
Dr. D. Hayes Agnew, of Philadelphia.
Mr. Adolph E. Borie, of Philadelphia.
And the meeting was adjourned.

Stated Meeting, May 3d, 1872.

Present, 18 members.

Vice-President, Prof. Cresson, in the Chair.

A letter accepting membership was received from Dr. D. Hayes Agnew, dated 1611 Chestnut Street, Philadelphia, April 22, 1872.

A Circular Letter, signed by the Mayor of Strasburg and others, requesting donations to the Municipal Library of that city, destroyed August 24, 1870, was read.

On motion, the request of Prof. Stevenson, to print a note to his Memoirs in the Transactions, was granted.

Donations to the Library were announced from the Royal Academies at Berlin and Brussels, the Geographical Society and Political Review of Paris, London Nature, the Canadian Naturalist, Old and New, Silliman's Journal, American Chemist, Prof. Mayer, the Franklin Institute, College of Physicians, Pennsylvania Historical Society, and Dr. Hayden.

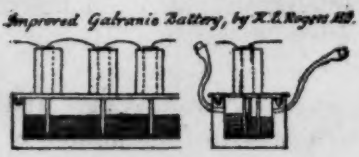
The death of John P. Brown, a member of the Society, at Constantinople, on the 28th ult., was announced by the Secretary.

The death of Dr. W. W. Gerhard, a member of the Society, at his residence, 1206 Spruce Street, Philadelphia, April 28th, aged 63, was announced by the Secretary.

Dr. Rogers explained to the members present his improved

Galvanic Battery; and also an improved method of analyzing irons and steels for their contained carbon, by the use of bichromate of potassium:

The wood-cut represents a trough, on which stands the battery of cups. A pair of tubes descend from each cup, through the lid of trough, into the liquids. The trough is divided lengthwise by a diaphragm. The tubes of each pair descend one on each side of the diaphragm. The lid of the trough is made air-tight, by the following arrangement: A groove is sunk in the upper edge of of the four walls of the trough, and a bead to fit the groove runs round the under side of the lid near the edge. The groove being half filled with mercury, the joint is kept air-tight by the weight of the lid and battery. An India-rubber pipe enters the trough, and the breath (or a bellows) is sufficient to cause the liquids to ascend into the cups of the battery during work. After work, the cork is withdrawn from the mouthpiece of the India-rubber tube, and the liquors fall back into the trough. The lid and battery can then be removed and washed.



Mr. Lesley described the faulted structure of the district around Embreeville, in East Tennessee; and exhibited a suite of European iron ores, owned by Mr. Thomas Graham, and another of the ores of North Carolina.

Prof. Cope described the sightless fauna of the Mammoth, Wyandotte, and other Caves.

Pending nominations, Nos. 693, 694, 695, were read,

And the meeting was adjourned.

Stated Meeting, May 17th, 1872.

Present, 13 members.

Vice-President, Mr. FRALEY, in the Chair.

A letter accepting membership was received from Professor Guillaume Lambert, dated Bruxelles, Rue Traversière, No. 78, April 30, 1872.

A letter acknowledging receipt of Transactions, XIV., i. ii., and Proceedings, 78–85, was received from Professor Paolo Volpicelli, dated del Campidoglio, Roma, Reale Acc. d. Lincei, December 12, 1871.

Donations for the Library were received from Gehe & Co., of Dresden, the Revue Politique, London Nature, the R. Astronomical Society, Cambridge Museum of Comparative Zoölogy, Boston Society of Natural Sciences, Buffalo Young Men's Association, Dr. Geo. B. Wood, Mr. Sol. W. Roberts, the Medical News, Penn Monthly, Petroleum Monthly, Wilmington Institute, and U. S. Corps of Engineers.

Professor Chase exhibited an annual Auroral Curve and explained its relations to the periodic maxima and minima of meteoric displays, &c.

Professor Chase exhibited a drawing to illustrate the capacity of Mr. Holman's pen to draw continuous lines of any length and thickness.

Professor Chase then gave in tabular form, various recently calculated planetary relationships.

Dr. Rodgers described his manner of obtaining an unlimited supply of electricity by the steam jet from a high-pressure boiler, not insulated, and in all weathers.

This gave rise to a discussion of electrical phenomena during volcanic eruptions and earthquakes.

Pending nominations, Nos. 693 to 695, and new nomination, No. 696, were read,

And the meeting adjourned.

Stated Meeting, June 21, 1872.

Present, 8 members.

Vice-President, Mr. FRALEY, in the Chair.

Photographs for the Album were received from Dr. Ed. Jarvis of Dorchester, Mass., Dr. Elisha J. Lewis of Philadelphia, and Judge W. H. Lowrie, of Meadville, Pa.

A letter accepting membership was received from M. Léon Say, dated Paris, 10th May, 1872.

Letters, acknowledging receipt of publications, were received from the Hungarian Academy, May 4, 1872 (XIII.,

3; XIV., 1, 2: 81-86); Herr G. Von Frauenféld, Vienna, 12, 1871 (82); Astronomical Society, Leipsic, February 20, 1872 (86); Royal Library, Berlin, March 1, 1872 (86); Royal Society, Göttingen, January 10, 1872 (XIV., 1, 2: 83, 84, 85); Royal Academy, Lisbon, October 5, 1871 (XIV., 1: 83, 84, 85); and the Smithsonian Institution, Washington, May 4, 1872 (XIV., 3).

Letters of envoy were received from the R. Society, Göttingen, January 10, 1872; the Central Statistical Bureau, Stockholm, April 8, 1872; Royal Saxon Society, Leipsic, October 31, 1871; Dr. Edward Jarvis, Dorchester, Mass., June 12, 1872; and the U. S. War Department, Signal Service Officer Albert J. Meyer, May 31, 1872.

Donations for the Library were received from Dr. Ed. Jarvis; also, from the Swedish Central Statistical Bureau, Russian Academy, Dorpat Observatory, Moscow Society of Naturalists, Austrian Geological Institute, Prussian Academy, Saxon Society, Lausitz Magazine, Göttingen Society, Zoological Garden at Frankfort, Vaudoise Society, Geological Committee of Italy, Montsouris Observatory, French Geographical Society, M. M. Delesse & Laparent, National Society of Antiquarians (Paris), Anthopological Society, Society of Acclimatation, Bureau des Ponts, &c., Revue Politique, Bordeaux Society of Sciences, London Royal Society, Royal Institution, Astronomical Society, Meteorological Committee, Chemical Society, Entomological Society, Cobden Club, Sir Henry Holland, Nature, Royal Society Dublin, Rev. L. Haughton, Essex Institute, Massachusetts State Library, Boston Public Library, Old and New, Silliman's Journal, Professor O. C. Marsh, American Chemist, Professor B. C. E. Anthon, Professor James Hall, Franklin Institute, College of Pharmacy, Medical News, Penn Monthly, Isaac Lea, J. C. Cresson, Lorin Blodget, the Secretary of the Interior, Census Bureau, Signal Service Bureau, and the California Academy of Sciences.

Dr. Emerson desired to have placed on record the destruction of Norway Fir, Arbor Vitæ, and Osage Orange, as far

south as the latitude of Philadelphia, either by cold or long drought, or both.

Professor Trego gave an account of the destruction in Germantown.

Mr. Blodgett added his notes of the Meteorology of March 5th, 6th and 7th, during which a cold, dry gale prevailed, to which he ascribed the loss of these plants. Fruit trees, when their time for flowering arrived, showed an inability to blossom for several weeks, as if paralyzed; the dryness of the gale of March seemed to have exhausted the sap. Many of the White Pines of the Alleghany Mountains were also killed.

Pending nominations, Nos. 693 to 696, and new nomination, 697, were read,

And the meeting was adjourned.

Note on a fine Upthrow Fault at Embreeville Furnace in East Tennessee.

By J. P. Lesley.

(*Read before the American Philosophical Society, May 3d*, 1872.

In a late visit to the works at Embreeville, on the Nolichuckee River, in Washington County, East Tennessee, I made a compass and barometer survey of the river valley and Bompas Cove, connecting the Furnace with its flux quarry and ore banks, tram road, washing ground, slack-water channel, etc., which will be found delineated on the accompanying map, drawn on a scale of 4,000 feet to the inch, with contour lines of 20 feet elevation to express the topography.*

* The accompanying map was hastily sketched for reproduction by Mr. Bien's photo-lithographic process. It merely shows the character of the topography of a portion of the property. But it is accurate so far as regards the course of the river, the hills which enclose it, the sand-rock outcrops, the north end of Bompas Cove, the grade contours of the railway and ravines, the elevation of the mines, &c. All the rest, including the heights and contours of the mountains, must be considered merely approximations to the truth. The contour lines represent elevations of 20 feet successively above tide-water, commencing at about 2,000 feet. The section below the map represents the geology along the river, above and below the Furnace. The scale was originally 1,000 feet to the inch. It was photographed down to 3,000 to make a plate. That plate was lost in the fire which rendered a second edition of this Number of the Proceedings necessary. An original copy from the first plate was then photographed down to 4,000 *feet to the inch*, to make the present plate.

Scale 4000 ft. to the inch.

The Furnace stands in the gap which the Nolichuckee makes through the last range of mountains on its way out from the North Carolina Highlands to the Great Limestone Valley of East Tennessee. A double rib of massive sandrock here forms a natural dam and mill-race, affording unlimited water-power, protected by projecting fragments of the sandrock outcrop from the most violent freshets. It is a scene of rare beauty, and a remarkably favorable location for any kind of industry requiring power. A broad terrace affords ample room for several furnaces and their dependent outworks, a village, mills of different kinds, and, in fact, for a Rolling Mill of the first class.

At present there stands here one Furnace, of small size, making $6\frac{1}{4}$ (six and a quarter) tons of metal per day at the time of my visit, a saw mill, an ochre mill, a village, store, church, and Superintendent's mansion.

A rope-ferry communicates with the State Road on the opposite shore. Jonesborough—the capital of the county, and oldest settlement in the State, on the East Tennessee, Virginia and Georgia Railroad, 32 miles from Bristol, 98 from Knoxville, 210 from Chattanooga, 236 from Lynchburg, 440 from Norfolk, and 391 from Richmond—is eight (8) miles distant from the furnace by this State Road. A railway could be made without difficulty over these eight miles, along smooth vales of limestone land, which head up towards Jonesborough. My barometer along the State Road gave me 200, 300 and 340 feet as the summit elevations above the river at the ferry. The intervals were from 50 to 100 feet lower. Railroad grade at Jonesborough was something under 200 feet above the ferry. A line might be located with maximum gradients of 50 feet to the mile, and with little or no cutting and filling, except for the first half mile below the furnace in the gap. Ten or twelve thousand dollars a mile ought to be quite sufficient to build the road. The bridge at the Furnace would be 200 feet long, but would need no piers, nor abutments: these being provided by nature in the shape of colossal sandrock outcrops rising fifty feet above the river bed.

The metal made at the Furnace goes chiefly to the Tredegar Works at Richmond, 400 miles from the Furnace, costing $3.25 a ton to haul to Jonesborough, in the present state of the roads. In dry seasons, the limestone roads become smooth and hard.

Up the river to the south and east, locked in among hills of irregular trend, steep slopes, and bluffs of crumbling rock, from 600 to 1,000 feet high, lie two limestones coves: Bompas Cove, drained by Bompas Creek, flowing north into the river at the Furnace washing ground, two miles from the works; and Greasy Cove, drained by streams flowing southwestward to the river, and about six miles from the works.

Bompas Cove is an oval valley three or four miles long, by one and a-half wide at its widest part, surrounded by mountains about a thousand feet high, on the inner slopes of which rest terraces or hill-spurs of decomposed limestone (Lower Silurian) holding masses of brown hematite iron ore of two varieties; the lower series (and outer, or closer up to the

mountain wall) being silicious and cold-short, and the upper series being argillaceous and red-short. The cove is nearly encircled by the cold-short deposits, which have been opened in a number of places, and a good deal mined, towards the head of the cove, for an old furnace further south. The red-short hematites are extensively spread out more in the middle of the cove, where they are capped by lead-bearing members of the Limestone formation.

There are a few fertile farms in the cove; but an uninterrupted forest covers all the mountain country around it, most of which is included within the limits of the estate.

Greasy Cove is a large and nearly level limestone plain, more than twenty miles long by five miles wide, similarly surrounded by shale and sandstone hills nearly 1,000 feet high and backed by the State Line Range of the Unaka (Sub Silurian) Mountains more than twice as high. The Nolichuckee enters this cove from the mountain country to the south, and leaves it by a gorge, the south wall of which is a towering cliff of sandstone 500 or 600 feet in vertical height, called the Devil's Looking Glass. It flows thence three miles straight north-northwest towards the mouth of Bompas Cove, where it makes an ox-bow, and then flows north to the Furnace, as shown in the map.

This interval of three miles is made through forest-covered hills. Paddy's Creek and Broad Shoals Creek form narrow forest-covered valleys, entering the river valley from the southwest. Another stream of equal size forms a similar valley on the northeast. All this is good coaling ground for iron-works; and depots of charcoal can be established at different points on the two banks of the river, down which the fuel can be safely and cheaply boated. Two large charcoal furnaces at Embreeville could be erected in view of a constant supply of charcoal by the organization of an extensive system of coaling depots up the river. A forest surrounds the head of Greasy Cove and passes in an unbroken belt across all the hill country back of the river bottoms, over to the *Dry Creek Valley*, and Buffalo or Cherokee Mountain, north-northeast and east of the Furnace. This is on the east side of the river. On the west side, as I have said, many square miles of forest-covered hill country surrounds Bompas Cove.

This forest consists of white oak, spruce pine, poplar, hickory, etc., most of it in its original condition. Some tracts have been coaled off once, others twice. After fifteen or twenty years they are ready for coaling again. I saw a few trees two feet in diameter; but the forest trees are lighter than I am accustomed to see in Pennsylvania. They will probably yield, on an average, 40 or 50 cords to the acre, while some ravines will go up to 100.

The charcoal used at the Furnace is good and strong, but by the hauling over steep roads, and several handlings, the waste amounts to 25 or 30 per cent. Most of this could be saved under a more extensive and complete organization of this part of the business, and by the use of

large baskets on trucks. The coal floors are near enough the Furnace to allow the carts to go to it twice a day; some, however, can be reached but once a day. The dependence of extensive works must be on a river navigation and coaling depots above, as has already been said.

One hundred and ten bushels of charcoal go to the ton of iron at this furnace, making, say, six tons. An enlarged stack could easily make ten or twelve. The Shelby Furnace in Alabama, sixty feet high, is making at the present moment, with charcoal, sixteen (16) tons, by information I have indirectly from the keeper, although it is reported she has made twenty. The report is incorrect; she has never exceeded sixteen. But this shows what *can* be done with charcoal and brown hematite ore. In smelting rich fusible lump ore, one ton of metal requires from *one-third* to *one and a-quarter* tons of hard charcoal, or from *one and a-half* to *three* tons of soft charcoal.

Coke, however, is the future dependence of Embreeville Works on an extensive scale. The Cumberland Mountain, west of Knoxville, (Coal Creek, Cove Creek, etc.,) has numerous workable beds of good bituminous coking coals. The Knoxville and Kentucky Railroad is already carrying these coals from the mines to the factories and ironworks of Knoxville and other towns along the East Tennessee Railroad, including Jonesborough. Contracts can be made for the delivery of any amount of Cumberland Mountain (Waldron Ridge) coal at Jonesborough, for $3.25 to $3.50 per ton. If the eight mile branch to Embreeville were built, costing with bridge and rolling stock, say $150,000, the coal could be landed at the Furnace at a cost of something under $4, and there coked; or, which would be better, coking establishments could be organized in the Cumberland Mountains, along Cove Creek, and the coke be deposited at Embreeville for about $4.50, owing to the fact that—1. One-half the weight of the car-load would be saved by carrying it in the form of coke; 2. The waste in dust would be saved; and, 3. The slake waste at the mines would be coked with the lump.

Now, $6\frac{1}{4}$ cents a bushel is paid at the Furnace for charcoal, or, $6\frac{1}{4} \times 110 = \$6.87\frac{1}{2}$, to make a ton of metal.

Coke furnaces require from 1.1 to 2.3 tons of coke to make 1 ton of iron, according to their size, shape, and especially the quality of ores employed. For brown hematites it would not be safe to assume less than $1\frac{1}{2}$, and it might go up to $1\frac{3}{4}$ tons of coke to one of metal. If coke could be got at Embreeville for $4.50, the coke for 1 ton of iron would still cost $6.75, as against $\$6.87\frac{1}{2}$ for charcoal.

But while a charcoal furnace is producing 45 tons of metal a week, a coke furnace with hot blast is producing from 150 to 200 tons a week.

It would be unwise to erect more than two first-class charcoal furnaces at a point like Embreeville, in view of the extensive and complicated system of coaling and boating required. These would make 10 tons a day each, or 140 tons of metal per week. Whereas four coke furnaces might

be put in blast safely, making together (with one always out for repair, etc.), say 3×150—450 tons of metal per week; or even 600 or more.

On the other hand, no profit could be made on coke bought at the mines; and no profit on coal, but only on the coking of the coal at the Furnace, by supplying store goods for wages; whereas, the 6¼ cents per bushel paid for the charcoal is paid in stores, and a large saving accomplished.

The same is true of other labor, at the Furnace and at the mines; but this would not be changed by the substitution of coke for charcoal.

Another consideration, and one of importance, is the change in the quality of metal produced. So long as the lowest beds of the Cumberland Mountain system are mined, the coal will be second rate, and even if the best precautions are taken, the coke will not be so good a fuel as charcoal. Quality of metal would have to be sacrificed to some extent for the sake of quantity. The metal made at Embreeville could hardly be better than it is; exceedingly strong in the pig and much esteemed for car-wheel use. The price of such iron must always be high, whatever be the state of the seaboard and foreign markets, because of the limited amount of it made, and always to be made. Much, if not most, of the Tennessee iron must always be cold-short on account of the wide distribution of cold-short ores through the country.

The Brown Hematite, or limonite, deposits of Bompas Cove exactly resemble those of Morrison's Cove, Nittany Valley, Kishicoquilis, and other Lower Silurian limestone valleys of Pennsylvania and Virginia; and those of the long line of the north flank of the South Mountain (Blue Ridge, Smoky Mountain range) from the Hudson River to Alabama. They are in fact situated geologically just like the Allentown, Carlisle, and Chambersburg deposits.

These ores are irregular masses of ochreous clays and loose sands, full of shot and balls and pipes of the hydrated sesquioxide of iron; with coatings of the black oxide of manganese, and traces of the original sulphide of iron, sulphide of lead, and sulphide of zinc, held by the limestone strata before these were dissolved and made cavernous by the drainage waters which have packed the clay sand ore into all the holes and crevices, caves and water-courses thus made.

The general dip of the limestone beds in Bompas is about 10° north-northeast, against a fault which crosses the mouth of the cove and seems to run in a line about N. 15° W., S. 15° E. All the rocks to the east of this line—the rocks in which the river flows—are of an older age, and dip 60° S. 40° E., in very straight bold outcrops, as represented on the map and in the section accompanying it.

This gentle dip of the limestone has exposed several square miles of the ferruginous lower limestone to decomposition; and the quantity of ore is correspondingly great.

The limestone has been cross-cleft; its cleavage planes dipping 45°, more or less. The dissolution has followed these cleavage planes. The

ore-clays are packed in descending cavities sloping at that angle. The massive ore seems to dip 45° therefore, instead of 10°. But as several hundred feet of the nearly horizontal limestone beds has converted itself more or less into ore, the quantity of ore is immense.

The series of ore pits from which the furnace has supplied itself, ranges up the side of a steep hill, beginning at an elevation of about 200 feet above the river (one mile from it), and ending at an elevation of 350 feet. But the ore continues up the hill a hundred feet higher; and descends also below the lowest pit. No system has been observed in mining the ore. Everything has been done hap-hazard and in the most expensive way.

The stripping varies from a foot or two to twenty and thirty feet. The solid ore-ground, consisting of from one-half to four-fifths fine ore, the rest balls, with occasional masses of clay, and occasional masses of solid hard limestone rock (left in its original condition, but with all the edges dissolved round), has been dug into to a depth of ten, fifteen, twenty feet, and more in places, without reaching bottom.

I judged that I saw along the line of pits over the end of the tramway, about one million of tons of ore.

The ore can be followed over the top of the little hill and down its northern side.

Abundant evidence of ore covers the long slope of the hill towards the south for a quarter of a mile.

The same limestone beds take into the isolated hill to the west; and on both sides of this hill near its top are old diggings of the ore, from which the original furnace was supplied for a good many years, and abandoned when that furnace was abandoned, and the new Furnace was erected at Embreeville. The old furnace was situated on Bompas Creek, about half a mile southwest of the present ore mines, and just opposite the lead mine shown upon the map, but inconveniently far from the river.

There must be millions of tons of iron ore in the more central part of the cove, in the low hills composed of the almost horizontal ore-bearing limestone strata, which everywhere show the dissolving action of the ore-collecting waters, and are covered in many places with ore-ground.

The books of the Furnace show that after the ore has been washed and the large lumps roasted to make them more easily broken to pieces, the lowest percentage of ore to pig metal is 49, and the highest 59. The *practical average* of pig iron obtained from the thus prepared ore is fifty-five per cent.*

* Analysis of Brown Hematite ore from Bompas Cove, E. T., made by Prof. Fisher, of U. S. Naval Academy, Annapolis, Md.:

Water and organic matter,	13.15
Phosphoric acid,	.09
Silica,	3.05
Alumina,	1.28
Sesquioxide of manganese,	.27
Sulphur,	.308
Peroxide of iron,	82.27
	100.313

82.27 peroxide of iron equals 57.6 per cent. pure iron.

The weight of the washed ore when dry is one and a half ($1\frac{1}{2}$) tons to the cubic yard. The weight of the lump ore is about $1\frac{1}{4}$ tons to the cubic yard. One car-load of 44,919 cubic inches measurement, *thoroughly dried wash ore*, weighed 3,042 lbs. One cubic yard = 46,656 inches. The lump ore of one car weighed 2,570 lbs.

Very little flux is required by the Furnace, and this is obtained from bold outcrops of blue limestone on the State Road two-thirds of a mile north of the ferry. There is so much lime in the wash ore and in the clay of the ball ore, and so heavy a charge of manganese in the ore deposit that the fluxing of the stock scarcely adds to the expense of its smelting. The cinder is excellent and the waste of iron is evidently small.

Around the inside lining of the tunnel head for about four feet down from the lip of the filling-hole, there forms a coating of concentric layers of a very solid and heavy substance, consisting chiefly of metallic zinc, in alloy with metallic lead and a small quantity of metallic iron.*

The upper and more solid blue and white limestones of Bompas Cove, exposed along the banks of the creek, opposite the old furnace site, contain a good deal of disseminated galena. This is decomposed into carbonate of lead, filling crevices which have been followed down by shafting operations during the late war. The two ores of lead were taken in cars, on a tram road a few hundred yards long, down the creek to a lead mill erected by General Jackson, and there smelted for the use of the Confederate army. The works are now abandoned, and the shafts filled with trash or water.

Brown hematite iron ore deposits have also resulted from the decomposition of the limestone beds over the lead-bearing strata.

Greasy Cove is a district of limestone similar to, but much more extensive than Bompas Cove, and carries the same brown hematite iron ore deposits of probably equal size. The hills overlooking the flat land of this cove on the northwest and within half a mile of the river, are red with ore.

* Analyses, by Persifor Frazer, Jr., Assistant Professor of Chemistry in the University of Pennsylvania, of—

I. *Furnace product* from Embreeville Works, N. C., taken from within four feet of the tunnel head: A hard, brittle, gray solid, with occasional streaks of green, but in powder is grass-green. Specific gravity, 5.6.

Under the magnifying glass it shows minute metallic scales which impart a metallic lustre to the streak when the product is scratched, and yet bear such a small proportion to the whole mass that they are almost indistinguishable with the naked eye.

Silica,	0.28
Iron (calculated as sesquioxide),	4.12
Zinc (oxide),	84.26
Lead (metallic),	6.18
Carbon (as finely divided coal dust determined by loss),	5.16

II. *Lining stone* of Embreeville Furnace, N. C. A yellow sandrock used for the lining of the Embreeville Furnace, and remarkably lasting, was proved to contain:

Silica,	76.99
Alumina and Iron (latter under 2 p. c. Fe_2O_3),	16.12
Magnesia,	2.63
Lime,	1.44
Undermined,	2.83

Considerably more than 50 per cent. of the Silica given above seems to exist as free Silica, or sand.

These details are not only interesting in themselves, but necessary for familiarizing the observer with the scene of a geological action, common enough in our Appalachian region, but rarely exhibiting itself in so bold and telling a way as at Embreeville.

A fault—an uptl:ow and overshove—a collapsed synclinal at the edge of the thrown-down mass—all this is presented to the eye of the structural geologist, as he stands on the steps of the little Church of Embreeville and looks across the river eastward. Hundreds of feet of limestone outcrop, in part natural cliffs, in part quarry work, demonstrate the problem of Cambrian overlying Silurian—the Quebec Group overriding Trenton Limestone—by drawing it in a grandly visible diagram, a mile long, by 800 feet high.

The solid plates of limestone are bent round in the synclinal without fracture (other than at the great cleavage planes) as though they had been as plastic as wax. A slight anticlinal roll immediately precedes the sudden upturn to a vertical followed by a declining angle in the reversed sense. The exact place of the fault is obscured by a general crush and sheet-covering of the finely broken shale and very thin bedded shaly sandstone layers which make the rest of the mountain mass.

Up through these sandy shales, dividing them into an upper and lower system, rise the bold outcrops of two conglomerate beds, each about 20 feet thick. One of them, forming the crest of the mountain east of the river, descends in a dyke to the water, sinks under the valley, and reappears to face the slopes at the bend at the mouth of Bompas Creek. The other forms a dyke along the foot of the mountain from the Furnace southwest to Bompass Cove. These two coarse sandrocks or finely brecciated conglomerates are shown in the diagram at the foot of the map on page 445, above.

It will be noticed that another set of sandrocks, not at all conglomerate, but semi-crystalline in texture, and (with alternations of softer kinds, and shale bands) at least 100 feet thick, come in above and (being nearly horizontal) cause that hog-back topography seen in the horseshoe bend of the river. It will be noticed also that above these last sandrocks, lies a third or uppermost system of sandy shales. These constitute (with some still higher intercalated massive sandrocks) the bulk of the inwalling river hills (600–800 feet high) all the way up (about 3 miles) to the entrance into Grassy Cove; that is, to the next parallel fault throwing down the Silurians.

It will be evident to those familiar with this characteristic structure of East Tennessee and Southwest Virginia, that the Nolichuckee River exposes a nearly transverse cross-section of a long prism of earth-crust composed of sandy shales, sandrocks and conglomerates, at least 600 feet thick, *elevated* between enclosing *sunken* countries of Lower Silurian Limestone.

There is no sign of squeeze and distortion along the southern (Greasy Cove) fissure, for the uplifted upper shales abut there horizontally against

the down-thrown limestone prism to the south of it. Whereas in the Embreeville (or northern) fault, the lower part of the shale prism has been lifted and thrust violently against the limestone prism to the north, so as not only to override it, but to curl up the ends of its beds into a collapsed synclinal. The force has therefore come from the south, and acts northward, or north-northwestward. This is not only in accordance with the law of anticlinal structure, made out in Pennsylvania by the survey under Prof. H. D. Rogers, 35 years ago, but with nine-tenths of the fault exhibitions in Virginia and Tennessee.*

What the rock system is, a prism of which has thus been upheaved between the two Lower Silurian districts of Jonesborough to the North, and Greasy Cove to the South, is still a subject for discussion. Mr. Safford, State Geologist of Tennessee, gives it the name of Chilhowee, without identifying it closely with any of the great Formations of the Northern States. It probably underlies immediately the Lower Silurian Limestones.

One thing is remarkable: its apparent total lack of iron ore and limestone. There is no appearance of metamorphism throughout the 6,000 feet of rock trenched by the Nolichuckee.

The cross-fault of Bompas Cove, on the west side of which the L. Silurian Limestones are dropped to water level in an almost undisturbed (horizontal) condition, is, perhaps, the most interesting feature of the dynamic scene I am trying to portray; but it must remain for some geologist to study who has more time at his command than I had, in my hurried visit to Embreeville.

These cross-faults are incidentally mentioned by Mr. Safford, on page 200 of his Report of the Geology of Tennessee for 1869, when he says:

"484. At the ends of these mountains, the sandstones which form them are suddenly and curiously cut off, and wholly disappear. The mountains and their rocks, of course, lie generally immediately on the southeast side of a fault. The sandstones, broken in wide blades, appear to have been thrust up endwise to the northwest, through the overlying formations. The displacement is, in some cases, very great. In the case of Chilhowee Mountain (see section page 190), the sandstones, or, rather, Ocoee conglomerates, have been brought up and abutted against *Carboniferous Limestone.*"

The expressions used in the above description are calculated to obscure the picture to the eye of the reader. The sandstones are prominent objects in the landscape; but they are integral and very subordinate items in the mass of the upthrown (and often but slightly tilled) prism of earth-crust. To a depth unknown to the observer, the earth-crust in all this region of Virginia and Tennessee has been cracked along straight, parallel lines of great length (some of them a hundred miles), but of no

* I have recently exhibited to the Society cross-sections of this structure, in Tazewell, Wise, and Scott Counties, Virginia, which, when published in the next Number of these Proceedings, will make this law sufficiently comprehensible.

great width, seldom over five miles. In Mr. Safford's Section (page 190), across Eastern Tennessee, from the carboniferous table-land, southeastward to the Metamorphic Azoic Mountains of the North Carolina line, 52 miles, there are *eight* of these faults noted, making the average width of each prism (supposing no fault has been omitted) 6½ miles.

The upthrow or override of the side face of each prism against the prism to the northwest of it, varies from fifteen thousand (15,000) feet (as in the Chilhowee Mountain Fault above cited, and in the Montgomery and Wythe County Faults of Virginia) down to five thousand, as in the case of the Embreeville Fault, and others of a like kind, in the same range, where the bottom measures of the Chilhowee, or top measures of the Ocoee, Formations abut against the Trenton Limestones.

The tilt of a prism, five miles wide to an elevation of only one mile on its northwest border, gives an average dip of 1 in 5, or 10°. But the tilt has been produced by a thrust from the southeast, violent enough not only to produce the tilt, and thrust the prism forward and upward, but to rub up the broken edges of the layers of the down-tilted next prism, and to rub down the broken edges of its own layers; and, moreover, to bend the whole body of the prism along its northwestern limit. Consequently we have *there* dips of 45°, whereas the dips everywhere else (with trifling exceptions) are scarcely more than 5°.

It may be said, therefore, if astonishment be expressed at the vastness of these upthrows, considering the weight of the prism, that, in fact, there has not been so much upward movement after all.

On the other hand, in the sections I have made across sets of these faults, in other parts of the region, and where the uptilt is of lower Silurian Limestone against Coal Measures, repeated again and again, the proportion of horizontal to vertical is as 5 miles to 3 miles, and a dip of 30° pervades the entire body of the prism, and of *each* prism, from side to side.

This is a very astonishing state of things. And it characterizes a region of country fifty miles wide by five hundred miles long, roughly stated.

What supports these long untilted prisms of earth-crust?

We cannot imagine an underground Pre-silurian topography arranged with such regularity, as to allow the settlement of the sections of Paleozoic series, in straight lines, hundreds of miles long, and always on one side, the southeastern.

It seems to me evidently necessary to assume a (in some sense) plastic underground, on which these wonderfully regular prismatic rods of Paleozoic rock have been able to roll one-third over and adjust themselves.

The alternative must be, that the vacancies (of triangular section) have been filled with the debris of the lower crushed edges and bottoms of the prisms,—a most unsatisfactory suggestion—especially unsatisfactory, because the regular over-roll of all the prisms in one direction

proves that the laterally acting energy (whatever may have been its origin) was acting on a great plate of Paleozoic rockmass, at least (counting in the coal measures) *four miles thick;* solid, although flexible, itself; but free, when broken, to slide on its foundations, as the broken up flakes of ice slides over the water which supports them.

That there was no absolutely fluid (lava?) underground beneath them is evident from the total absence of volcanic rocks at the present eroded surface, along these faults, even when the uppermost *Subsilurian* rocks appear in one wall. (The numerous warm springs connected with the Virginia faults are explicable on chemical principles, no doubt.) But beneath the uppermost Subsilurians are vast formations, all more or less metamorphosed, and many converted into granites and other crystalline forms. Here we have the plastic mass we need, over the surface of which (of course, an eroded surface, but, probably, eroded to a plane containing no Alpine or even Subalpine inequalities) the Paleozoic deposits, consolidated by time into a consistent, but never yet dried, sheet, seven miles thick in Pennsylvania, five miles thick in Virginia, three miles thick in Tennessee, moved with a certain freedom, under a lateral pressure, from the southeast, at the close of the Coal Era.

I have formerly taken occasion to ascribe the difference of effect exhibited by this pressure in Pennsylvania and in Tennessee to the difference in the thickness of the Paleozoic mass. In Pennsylvania it was folded; in Tennessee dislocated. But the difficulty which pressed on Mr. Rogers to explain the sustentation of the vaults of our Northern anticlinals, is encountered equally by the Southern geologist who will explain the stable equilibrium of his tilted prisms.

To return from this digression to the cross fissures, which cut off the ends of the Chilhowee and other mountains (and an example of them is given in my map of Bompas Cove), it must be understood that they do not obey one law, as do the principal and parallel dislocations of the country. They sometimes run square across from one of these to or towards another; seldom cutting a prism entirely off; usually cracking its north western edge for a certain distance into its body. It is a subordinate and secondary system of faults. But by means of it most of the Appalachian ridges or mountains, of Middle Silurian and Upper Divonian age, are swallowed up and ended at the surface; just as are the mountains of Chilhowee sandstones, in such cases as that described by Mr. Safford above.

The section accompanying my map will, perhaps, be compared by some reader of this paper with Mr. Safford's section on page 202, and they will be seen to be very different. It is only needful to explain that my section was made with instruments on the ground under favorable circumstances, and carefully drawn to the same horizontal and vertical scale; whereas the section on page 202 is like Mr. Safford's other sections, drawn to a vertical scale at least twenty times greater than the horizontal, and, as he says, "it is not intended to be accurate in detail."

In fact nothing can be more erroneous than the impression on the mind

of a young geologist produced by the section. It not only distorts the facts, but bars the way to a right understanding of the structure not only of this locality at Embreeville Gap, but of similar localities along the Unaka Mountain range.* There are no such synclinals as are there represented. There is nothing which in the remotest sense resembles the anticlinal there drawn under the letter D. That interval is essentially and wholly monoclinal.

Every student of American geology must acknowledge his great indebtedness to the assiduous and judicious State Geologist of Tennessee, who has done so much to elucidate one of the most interesting regions of the United States. Among the many valuable columns of thicknesses which he has published, the following (in § 489) justifies the statement I have made relative to the amount of rock visible along the river above Embreeville. It represents the Chilhowee Group, in Doe River Gap, Carter County.

Top of Section :—Quartzose sandstone	55 feet.
Sandstones and Shales	70
Quartzose Sandstone	10
Sandstone and Sandy Shales	250
Quartzose Sandstones	35
Sandstones and Sandy Shales	370
Quartzose Sandstone	40
Thick and thin bedded Sandstone, generally dark colored, occasionally Sandy Shales, and but little fine conglomerate	1,720
Quartzose Sandstone	40
Thin Sandstones and Sandy Shales	320
Sandstones and fine conglomerate with two Quartzose bands	275
Heavy bedded Quartzose Sandstone	38
Sandstone not well seen	180
Heavy Gray Quartzose Sandstone, with unimportant layers of fine conglomerate	60
Sandstones with conglomerate, dark and even bedded	44
Heavy Gray Quartzose rock, mostly sandstones with fine conglomerate	60
Some of the Sandstone hard and Quartzose	472

The lower part of my Embreeville Section consists of between one and two thousand feet of sandy shales, with two very massive plates of conglomeratic sandstone, about twenty feet thick. Two or three thousand

* With the highest respect for the distinguished services rendered our science by the State Geologist of Tennessee, I cannot refrain from expressing regret that the weight of his standing in the science should be thrown into the scales on the side of the slovenly and mischievous fashion of distorted drawing in vogue among geologists until recent years. A section is worse than worthless which is not well and truly drawn. It is sure to manufacture and perpetuate false views.